U.S. Army Research Institute
for the Behavioral and Social Sciences

Research Report 1949

Non-Cognitive Predictors and TSC 3B Market Expansion: Examining MOS Impacts

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July 2011

U.S. Army Research Institute for the Behavioral and Social Sciences

Department of the Army Deputy Chief of Staff, G1

Authorized and approved for distribution:

MICHELLE SAMS, Ph.D.
Director

Research accomplished under contract
for the Department of the Army

Human Resources Research Organization

Technical Review by

Brian Tate, U.S. Army Research Institute
Leonard White, U.S. Army Research Institute

NOTICES

REPORT DOCUMENTATION PAGE

1. REPORT DATE (dd-mm-yy) July 2011	2. REPORT TYPE Final	3. DATES COVERED (from. . . to) Nov 2008 – Aug 2010

4. TITLE AND SUBTITLE Non-Cognitive Predictors and TSC 3B Market Expansion: Examining MOS Impacts	5a. CONTRACT OR GRANT NUMBER DASW01-03-D-0015 / DO 0053
	5b. PROGRAM ELEMENT NUMBER 622785
6. AUTHOR(S) Paul J. Sticha, Tirso E. Diaz, and Elise A. Weaver (Human Resources Research Organization); Peter M. Greenston (U.S. Army Research Institute)	5c. PROJECT NUMBER A790
	5d. TASK NUMBER 329
	5e. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Human Resources Research Organization (HumRRO) 66 Canal Center Plaza Suite 700 Alexandria, VA 22314	8. PERFORMING ORGANIZATION REPORT NUMBER FR 10-19
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) 2511 Jefferson Davis Highway Arlington, VA 22202-3926	10. MONITOR ACRONYM ARI
	11. MONITOR REPORT NUMBER Research Report 1949

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

Contracting Officer's Representative and Subject Matter POC: Peter M. Greenston

14. ABSTRACT *(Maximum 200 words)*:

ARI has been investigating the potential that non-cognitive predictors could play in expanding the supply of highly-motivated AFQT test score category (TSC) 3B applicants. The initial research effort was known as the Expanded Enlistment Eligibility Metrics (EEEM) project, and preliminary results were encouraging: non-cognitive predictors have been tested that appear to identify a subset of TSC 3B applicants with predicted attrition (and possibly job performance) comparable to that of TSC 1-3A applicants. One concern regarding the implementation of these new predictors is whether an increase in TSC 3B applicants and a corresponding decrease in TSC 1-3A applicants would have repercussions for Army MOS TSC 1-3A goals. The objective of this effort is to estimate the effect of illustrative increases in the number of TSC 3B applicants on the allocation of applicants to their initial MOS training. The objectives were addressed with application of the Enlisted Personnel Allocation System (EPAS) model, designed to simulate the allocation / classification process.

15. SUBJECT TERMS
enlisted selection and classification, Enlisted Personnel Allocation System (EPAS), non-cognitive predictors, Soldier Quality Accession Goals

SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON
16. REPORT Unclassified	17. ABSTRACT Unclassified	18. THIS PAGE Unclassified	Unlimited	46	Ellen Kinzer Technical Publication Specialist 703/545-2445

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July 2011

Army Project Number	**Personnel, Performance**
622785A790	**and Training Technology**

NON-COGNITIVE PREDICTORS AND TSC 3B MARKET EXPANSION: EXAMINING MOS IMPACTS

EXECUTIVE SUMMARY

Research Requirement:

The Army G-1 and the Commanding General, Training and Doctrine Command (CG, TRADOC) are supporting research by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) to investigate the potential that non-cognitive predictors could play in expanding the supply of highly-motivated AFQT test score category (TSC) 3B applicants. The initial research effort was known as the Expanded Enlistment Eligibility Metrics (EEEM) project, and preliminary research results were encouraging: non-cognitive predictors have been tested that appear to identify a subset of TSC 3B applicants with predicted attrition (and possibly job performance) comparable to that of TSC 1-3A applicants (D. Knapp and T. Heffner, 2010).

One question is how increases in TSC 3B applicants and a corresponding decrease in TSC 1-3A applicants (however operationalized) would affect the Army's ability to meet its Military Occupational Specialty (MOS) TSC 1-3A accession goals, as the MOS for which the TSC 3B applicants qualify are disproportionately filled with TSC 3B accessions. The objective of this effort is to estimate the effect of an (illustrative) increase in the proportion of TSC 3B applicants on the allocation of applicants to their initial MOS training.

Method:

We simulated the allocation of applicants to their initial MOS using the Enlisted Personnel Allocation System (EPAS). Using EPAS as a descriptive, as opposed to prescriptive, model required changes to the definition of applicant supply groups, as well as changes to the objective function that is maximized by EPAS in order to represent more closely current allocation priorities. The simulations were comprised of a baseline case – with requirements based on the FY2009 accession mission – and policy test cases reflecting the addition of 2,000, 4,000, and 8,000 highly motivated TSC 3B applicants to the appropriate supply groups and proportional reduction of other supply groups. The policy impacts were measured by the degree to which overall and specific MOS TSC 1-3A goals were met under set-aside assumptions.

Findings:

Incorporating additional highly motivated TSC 3B applicants, while maintaining a constant supply population, would decrease the percentage of TSC 1-3A applicants. However, the results of the simulation across all enlisted MOS indicate that if the additional applicants are set aside in calculating TSC 1-3A goals, approximately 8,000 highly-motivated 3B applicants can be added to the supply while maintaining the Army's ability to meet its overall MOS Soldier TSC 1-3A goal. After setting aside the additional TSC 3B applicants, the percentage of applicants in TSC 1-3A rose from 62.7% in the base case to 64.1% in the case with 8,000 additional TSC 3B applicants. The additional TSC 3B applicants had varying effects on the TSC

1-3A percentage fill of individual MOS, with TSC 1-3A fill increasing for some, while it decreased for others.

Utilization and Dissemination of Findings:

The EPAS model captures the interactions of the major elements in the classification process: the number and composition of expected applicants, MOS training seat availability, MOS fill requirements and TSC 1-3A accession goals, Army delayed entry program policy and overall accession requirements. Using EPAS as a descriptive model has provided insight into the potential classification effects of accession initiatives such as the EEEM initiative. We believe that such simulations offer the additional ability to manage applicant flow to mitigate the effects of these and other changes in recruit potential.

NON-COGNITIVE PREDICTORS AND TSC 3B MARKET EXPANSION: EXAMINING MOS IMPACTS

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NON-COGNITIVE PREDICTORS AND TSC 3B MARKET EXPANSION: EXAMINING MOS IMPACTS

Introduction

The Army G-1 and the Commanding General, Training and Doctrine Command (CG, TRADOC) are supporting research by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) to investigate the potential that non-cognitive predictors could play in expanding the supply of highly-motivated test score category (TSC) 3B applicants.[1] The initial research effort was known as the Expanded Enlistment Eligibility Metrics (EEEM) project, and preliminary research results were encouraging: non-cognitive predictors have been tested that appear to identify a subset of TSC 3B applicants with predicted attrition (and possibly job performance) comparable to that of TSC 1-3A applicants (D. Knapp and T. Heffner, 2010).

One concern regarding the implementation of these new predictors is whether an increase in TSC 3B applicants and a corresponding decrease in other applicants will have repercussions for Army classification. Specifically, an increase of 3B applicants would likely come up against Military Occupational Specialty (MOS) Soldier TSC 1-3A accession goals, as the MOS for which the 3B applicants are qualified are disproportionately filled with lower aptitude accessions. And so there is a question of the feasibility of bringing in the additional 3B applicants within the existing MOS cut scores and training management constraints.

Objectives

The objective of this effort is to estimate the effect of an (illustrative) increase in the number of 3B applicants screened-in, and a corresponding decrease in the number of other applicants, on the allocation of applicants to their initial MOS. Specifically, we investigated the extent to which increasing the proportion of 3B applicants makes it more difficult to meet MOS Soldier TSC 1-3A goals – whose purpose is to insure the requisite distribution of higher scoring Soldiers across MOS – or otherwise restricts the ability of the Army to meet its training management goals. The objectives were addressed with application of the Enlisted Personnel Allocation System (EPAS) model, an automated allocation / classification tool.

Organization of report

This report describes the activities that were conducted to (a) refine the definitions of the applicant supply groups (SGs) used in the EPAS optimization, (b) modify EPAS input files to represent conditions in Fiscal Year (FY) 2009, (c) modify the EPAS objective function to represent more closely current (rather than optimal) allocation priorities, and (d) estimate the effect of additional highly motivated TSC 3B recruits on Army ability to meet TSC 1-3A goals. The first activity undertaken was replacing the EPAS server and restoring the information contained in it; this is described in Appendix A.

[1] The Armed Services Vocational Aptitude Battery (ASVAB) is the cognitive test battery given to all recruits before contracting. The Armed Forces Qualification Test (AFQT) is comprised of several ASVAB subtests, and its scale is broken down into test score categories. TSC 1-3A includes persons scoring at the 50th percentile and above. TSC 3B includes those scoring between the 31st and 49th percentile.

Defining EPAS Supply Groups

EPAS uses supply groups (SGs) as a surrogate for individuals in the assignment process.[2] Although the version of the EPAS optimization used in the EPAS field test (Sticha, Diaz, Greenston, McWhite, 2007) allowed for a greater number of supply groups (SGs) than previous versions, no attempt to increase the number of SGs or to change their definition had been made. The EPAS Functional Description (FD; Greenston et al., 2001) described the methodology that was used to define the 150 SGs used in the field test. A two-stage strategy was used to define supply groups. The first stage defined macro clusters, based on gender, AFQT category, and education level. The second stage used cluster analysis to define individual SGs within each macro cluster, based on similarity of ASVAB and Aptitude Area (AA) scores.

In the EPAS field test, Sticha et al. (2007) made several recommendations regarding changes to the SGs that might lead to improved fidelity of EPAS allocations. Specifically, they recommended that different clustering methods be considered for TSCs 3B and 4 than are used for TSC 1-3A. Since applicants in TSC 1-3A qualify for many MOS, clustering by ASVAB scores, as is currently done, was thought to be a reasonable basis to partition them into SGs. However, for applicants of lower aptitude who qualify for relatively few MOS, clusters based on ASVAB subtest scores may not adequately characterize the aptitudes of all their members, potentially allowing EPAS to allocate a supply group to an MOS for which a substantial portion of its members are not qualified. Consequently, Sticha et al. recommended the development of more narrowly focused supply groups that better characterize their members. In addition, since the current research focuses on applicants in TSC 3B, it makes sense to elaborate on the SGs in that category.

Cluster Analysis to Define Supply Groups

Although the clustering method used to define the SGs generally followed the procedure specified in the EPAS FD (Greenston et al., 2001), we made the following three changes to the procedure: (a) The total number of SGs was increased by more than 60%; (b) the proportion of SGs allocated to macro clusters representing TSC 3B applicants was increased; and (c) the distance metric used in the clustering procedure was modified to incorporate both ASVAB scores and eligibility for specific MOS.

Overview of Clustering Approach

The EPAS FD specified a two-step clustering procedure to define SGs. In the first step, macro clusters were defined based on a three-way classification of supply by gender, TSC (1-3A, 3B, or 4), and education level (high school diploma graduate [HSDG], senior, or non-graduate). Because of the relatively small proportion of applicants in TSC 4, applicants in this group were not classified by education level, producing a total of 14 macro clusters. In the second step, a K-means clustering algorithm was used to form SG clusters within each macro cluster, using a pre-specified number of SG clusters per macro cluster. The distance metric used to define the SG clusters reflected differences in ASVAB subtest score profiles among applicants. The number of

[2] Without the use of SGs the EPAS linear programming model (as formulated) would be too large to solve.

SGs within each macro cluster was determined so as to reflect the relative number of individuals in the macro cluster, to equalize the variance in ASVAB scores within SG clusters, and to oversample some smaller macro clusters.

Since SG characteristics are used by EPAS to assign SG to MOS, the accuracy with which the allocation reflects what would have occurred if applicants were assigned individually depends on the extent to which all members of a SG qualify for the same MOS. Clustering by ASVAB scores by no means guarantees that SGs will be homogeneous with respect to MOS eligibility. To rectify this problem, we incorporated MOS eligibility into the clustering process, so that individuals who were eligible for the same set of MOS would tend to be in the same cluster. In this way, the resulting SG-MOS connections would be a better approximation of the individual-MOS connections.

Description of Clustering Procedure

Each MOS has an expression indicating the cut score on one or more Aptitude Area (AA) scales that qualifies an applicant for classification into that position. Since more than one MOS might have the same cut score expression (e.g., the following MOS require a combat (CO) AA score of at least 87 for qualification: 11X1, 19D1, 19K1, 21B1, 21C1), there are only 51 unique cut score expressions that define the qualifications for all entry-level MOS.

Definitions for the enhanced SGs were based on data contained in an extract of the Regular Army (RA) Analyst database provided by the sponsor. The extract included approximately 225,000 Army applicants from FY 2006-2008. Applicant information contained in the file included ASVAB test scores, AA composite scores, and contract date, as well as other variables. Based on this information, we defined dummy variables that related each applicant to each of the 51 unique MOS expressions. We conducted a principal components analysis on the dummy variables to obtain a smaller set of 18 factors, representing 95% of the variance of the dummy variables, to be used in clustering. Each applicant had a profile across these 18 factors representing the kinds of MOS he or she did or did not qualify for.

We then used a K-means clustering algorithm to form SG clusters within each macro cluster, using a distance function that incorporated both the ASVAB profile and the MOS eligibility profile. The relative weight of ASVAB scores and MOS eligibility was set by calculating the cluster structure using several sets of weights and comparing the solutions using the following two measures of cluster homogeneity:

- *Supply group homogeneity for ASVAB profile*. This measure assessed the extent to which a cluster solution reduced the within-cluster variance of ASVAB scores, compared to the ASVAB score variance for a single-cluster solution (within a given macro cluster). Higher values for this measure indicate greater supply group homogeneity with respect to ASVAB profiles.
- *Supply group homogeneity for MOS eligibility*. Supply groups are homogeneous with respect to MOS eligibility if SG qualifying rates for MOS are close to either 0% or 100%. We constructed an MOS eligibility homogeneity measure for SGs within each macro cluster in three steps. First, we transformed $p_{i,m}$, the *i*th SG's qualifying rate for the *m*th

MOS cut score expression using $p2_{i,m} = \max\left(p_{i,m}, 1 - p_{i,m}\right)$. The value of $p2_{i,m}$ will be close to 1.0 if most individuals in the *i*th SG qualify for the *m*th MOS or most do not. Second, we calculated the 10th percentile to summarize $p2_{i,m}$ values across SGs for a given MOS cut score expression. This statistic, denoted as $p2p10_m$, is the lowest $p2_{i,m}$ value for 90 percent of the SGs. It summarizes MOS eligibility homogeneity of SGs in the macro cluster for the *m*th cut score expression. Third, we calculated the percentage of $p2p10_m$ values that exceeded the threshold of 80%, to summarize MOS eligibility homogeneity of SGs across all MOS cut score expressions. A high percentage indicates that the SGs are homogeneous with respect to eligibility for most MOS.

To determine the best weighting for ASVAB scores and MOS eligibility to use in the distance function employed by the clustering algorithm, we calculated cluster solutions for several sets of weights, and plotted the two homogeneity values as a function of the relative weight placed on ASVAB scores. For instance, Figure 1 and Figure 2 show the plots for male

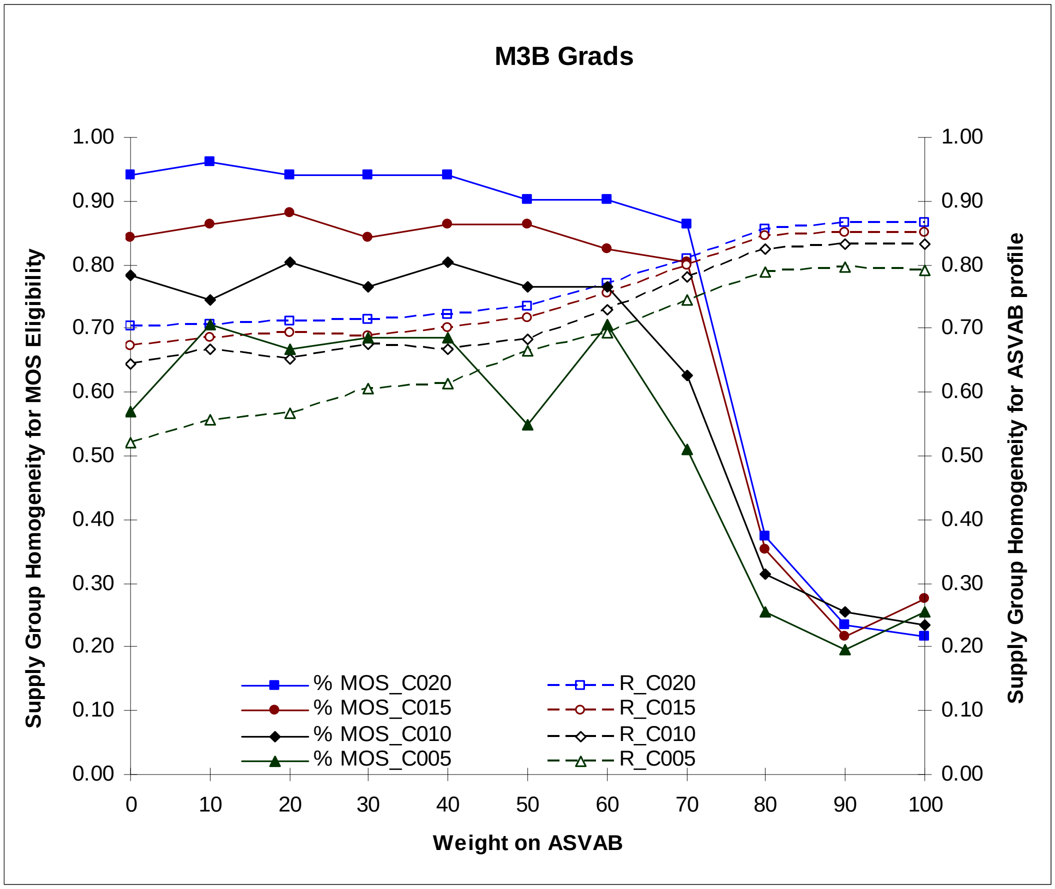

Figure 1. Homogeneity measures for male HSDGs in TSC 3B.

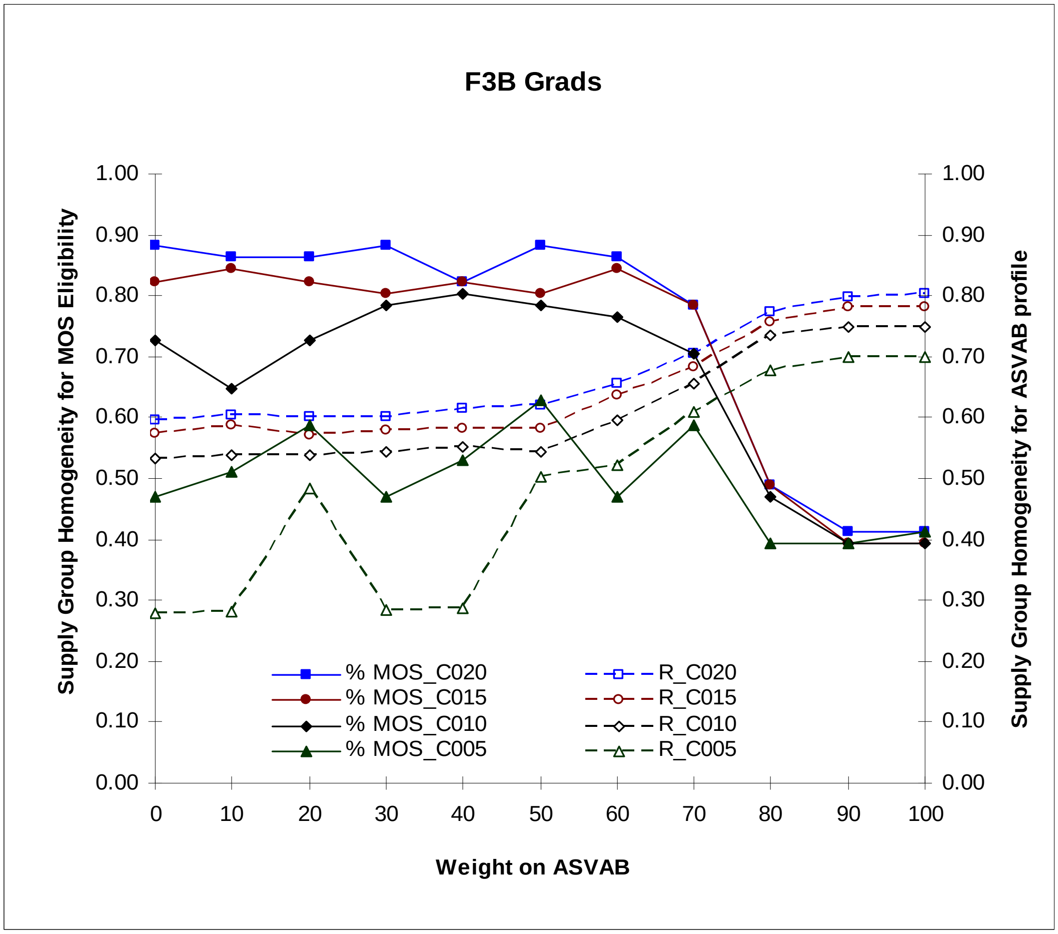

Figure 2. Homogeneity measures for female HSDGs in TSC 3B.

and female high school graduates in TSC 3B, respectively. Group homogeneity for MOS eligibility is shown with solid lines on the plot, while group homogeneity for ASVAB profile is shown with dotted lines. The individual lines represent solutions with more or fewer clusters. The lines labeled "C010" in the legend represent the baseline number of clusters for that macro cluster. Lines labeled "C005" represent a cluster solution with 50% as many clusters as the baseline, while lines labeled "C015" and "C020" represent 50% and 100% more clusters, respectively, compared to the baseline.

The figures show that, as expected, increasing the weight given to the ASVAB scores increases the SG homogeneity for ASVAB profiles, while it decreases the homogeneity for MOS eligibility. In general, the increase in homogeneity for ASVAB profiles is gradual and relatively modest, compared to the decrease in homogeneity for MOS eligibility, which shows a sudden and substantial drop at a weight of 60 or 70 (depending on the number of clusters in the configuration). Homogeneity varied unsystematically when the number of clusters was low, particularly for females. Increasing the number of clusters led to an increase in both homogeneity measures, with the biggest improvement usually occurring between the C005 and C010 level.

Plots such as those shown in Figure 1 and Figure 2, which were calculated for every macro cluster, were reviewed to decide on the number of clusters to include and the relative weight to put on ASVAB in the distance function. The complete set of plots is shown in Appendix C. Although there were differences between macro clusters in the details of the plots, the number of clusters specified by C010 and a relative weight for ASVAB scores of 60 yielded reasonable levels of homogeneity for all macro clusters. The resulting numbers of SGs by macro cluster are shown in Table 1, along with the corresponding number of SGs reported in the EPAS FD.

Table 1. Number of Supply Groups by Macro Cluster Compared to FD

Macro Cluster	Gender	Educational Status	TSC	Number of Supply Groups: FD	Number of Supply Groups: Current
1	F	HSDG	1-3A	12	19
2	F	Senior	1-3A	8	9
3	F	Non-Grad	1-3A	5	8
4	F	HSDG	3B	8	19
5	F	Senior	3B	7	11
6	F	Non-Grad	3B	3	10
7	F	All	4	9	10
8	M	HSDG	1-3A	26	26
9	M	Senior	1-3A	16	17
10	M	Non-Grad	1-3A	8	19
11	M	HSDG	3B	14	38
12	M	Senior	3B	9	19
13	M	Non-Grad	3B	4	22
14	M	All	4	21	19
Total				150	246

Characteristics of Highly Motivated TSC 3B Applicants

Research to develop expanded enlistment eligibility metrics (Knapp & Heffner, 2010) has identified characteristics of “motivated” TSC 3B applicants who would be most likely to perform at the level of Soldiers in TSC 3A. These non-cognitive characteristics are measured by the Tailored Adaptive Personality Assessment System (TAPAS; Stark, Chernyshenko, & Drasgow, 2010). Both Can-Do and Will-Do composites of personality traits were derived from TAPAS variables that correlate with skill and motivation. The Can-Do score correlates positively with measures of job knowledge, average Advanced Individual Training (AIT) exam grade and graduation from AIT / One Station Unit Training (OSUT). It is a unit-weighted composite of Achievement, Non-Delinquency, Even-Tempered, Intellectual Efficiency, and Optimism scales. The Will-Do score positively correlates with physical fitness, lack of disciplinary incidents, adjustment to Army life, effort, discipline, peer support, and negatively correlates with six-month attrition. It is a unit-weighted composite of Achievement, Non-Delinquency, Even-Tempered, Attention-Seeking, and Physical Conditioning scales.

The researchers in the EEEM project developed a Tier One Performance Screen (TOPS), combining the Can-Do and Will-Do composites of the TAPAS with scores on the Armed Forces Qualification Test (AFQT) and educational credentials (Allen, Cheng, Putka, Hunter, & White, 2010). Those who pass the TOPS must meet the following criteria:

- They must be high school diploma graduates (i.e., in educational tier 1);
- They must have AFQT scores between 40-49, in the upper half of TSC 3B;
- They must score at or above the 50^{th} percentile of the non-cognitive Can-Do composite of the TAPAS; and
- They must score at or above the 50^{th} percentile of the non-cognitive Will-Do composite of the TAPAS.

We used results from the EEEM research to estimate the number of high TSC 3B applicants who passed the TOPS screen in the baseline supply. Baseline supply is the notational equivalent of the USAREC gross contract mission. This estimation used only the SGs in macro clusters 4 and 11 in Table 1, which represent TSC 3Bs who graduated from high school, and involved three steps. First, we estimated the total number of individuals in each SG with an AFQT score between 40 and 49. The estimates were obtained by computing the percentage of individuals in each SG with AFQT scores between 40 and 49 using historical data (FY 2006 to 2008), and then multiplying the percentages by the corresponding SG totals in the baseline supply. Second, we estimated the number of high-TSC 3Bs in each SG who would pass the TOPS screen. The estimates were computed by multiplying the percentages of high TSC 3B individuals who passed the TOPS screen, obtained from the EEEM project (Knapp & Heffner, 2010), by the estimated number of high TSC 3B individuals in each SG by gender. Lastly, we estimated the total number of high-TSC 3Bs in the baseline supply by adding the estimates across SGs.

In summary, out of the 86,961 total individuals represented in the baseline supply, the estimated number of TSC 3Bs passing the TOPS screen was 2,610; the remainder of 84,351 represents TSC 1-3A, TSC 3Bs failing the TOPS screen, and TSC 4 individuals. The percentages computed from the data collected by Knapp and Heffner (2010) of high TSC 3B high school graduates who passed the TOPS screen were 46.94% for females and 28.65% for males.

Defining EPAS Input Files based on FY 2009 requirements

Input files to the EPAS optimization are described in the EPAS software user guide (Sticha & Smith, 2008). The following sources were used to specify the input files.

- Input files used in the EPAS Field Test (Sticha, Diaz, Greenston, & McWhite, 2007). In many cases the relevant input data were unchanged from the values used in the EPAS Field Test, particularly for index files, which primarily contain element names and configuration information (e.g., the number of contract months).
- The Director of Military Personnel Management (DMPM) memorandum stating Fiscal Year 2009 Army Accession Missions. This memo, dated 3 October 2008, provided accession requirements by gender and month for nonprior service (NPS) accessions who enroll in initial skill training (termed “trainers”).
- The FY 09 Target Reports (produced by Accession Management Branch (AMB) / HRC), which provide both target accessions and current fill by month and MOS. We used reports dated 10 September 2008 and 7 October 2008 to estimate monthly accession targets by MOS and the fill by MOS at the beginning of the fiscal year.

- AMB "Build-To" spreadsheet, which includes accession requirements by month and MOS, estimates of Future Soldier Program – formerly known as the Delayed Entry Program (DEP) – losses, and an estimate of the number of available training seats by month and MOS.
- U.S. Army Recruiting Command (USAREC) gross contract mission by month and education tier (HSDG, Senior, and other). The total supply was set to equal the total gross contract mission. Both accession requirements and seats were also inflated to equal the gross contract mission in order to reflect the effects of DEP losses.
- FY 09 Soldier TSC 1-3A goals, showing the percentage of the recruiting mission and the number of accessions by MOS and TSC.
- MOS Aptitude Area cut scores.
- The data extract from the RA Analyst database. These data were used to estimate the likelihood that applicants from different SGs would qualify for each MOS. This estimate was the basis of the value function maximized by EPAS. In addition, the data were used to estimate DEP loss percentages by accession month as a check on estimates obtained from other sources.

Table 2 shows the primary sources of data used to estimate each of the index files that are used by the EPAS system, as enumerated by Sticha and Smith (2008). The index files primarily represent the constructs used by EPAS, including MOS, contract months, accession months, SGs, and so forth. As such, most of these inputs are unchanged from the versions used by the EPAS Field Test. However, the MOS names were updated to reflect any changes that occurred since the time of the field test. In addition, the SG names were changed to reflect the new groups derived for this project. Table 3 briefly describes how the other input data were determined. These input files contain the requirements, constraints, and other values that were used by the EPAS optimization.[3]

Table 2. Input Files Representing Indexes Used by the EPAS Optimization

File Description	Source
Names of the MOS using Advanced Individual Training(AIT)	EPAS Field Test input file
Accession months before date of analysis	EPAS Field Test input file
Accession months after date of analysis	EPAS Field Test input file
Names of the accession months in the first fiscal year of the analysis	EPAS Field Test input file
Names of the accession months in the second fiscal year of the analysis	EPAS Field Test input file
List of all accession month names in the analysis	EPAS Field Test input file
Names of contract months in the first fiscal year of the analysis	EPAS Field Test input file
Names of contract months in the second fiscal year of the analysis	EPAS Field Test input file
List of all contract month names	EPAS Field Test input file
List of MOS names	MOS Aptitude Area cut scores
Names of the MOS using One Station Unit Training (OSUT)	EPAS Field Test input file
A list of priority MOS names	EPAS Field Test input file
A list of supply group (SG) names	Generated from SG cluster analysis
A list of aptitude category group names	EPAS Field Test input file

[3] See Appendix B for enlarged versions of Table 2 and Table 3, containing actual file names and the additional files used in the more general EPAS model.

Table 3. Input Files Representing Requirements, Constraints, and Values Used by the EPAS Optimization

File Description	Source
Required accessions by accession month	NPS Trainer Accession Goals by month were obtained from the DMPM Memorandum. DEP loss adjustment taken from the Build-To spreadsheet, with a second proportional adjustment to match the gross contract mission. Initial fill, taken from the 7 October 2008 version of the FY2009 Target Report.
Accessions in TSC I-3A.	Taken from FY 09 Soldier TSC 1-3A goals, adjusted to represent gross contracts.
Available seats by MOS and accession month	Seats were set to be equal to accmssn.csv.
List of allowed combinations of contract month and accession month by supply group.	DEP policy for the analysis was the same as in the EPAS Field Test. This policy was applied to the new supply groups.
Indicates supply groups representing TSC 4	Based on SG macro cluster characteristics.
Indicates education level of each supply group	Based on SG macro cluster characteristics.
Indicates supply groups representing high aptitude applicants	Based on SG macro cluster characteristics.
Table indicates the gender of the member of each supply group	Based on SG macro cluster characteristics.
Scalar indicating limits on accessions in TSC 4	EPAS Field Test input file
Supply by supply group and contract month.	SG proportions were based on analysis of RA database.
Value of assigning supply group to MOS	Value was set to the qualification probability, based on the MOS requirements, and the SG aptitude distribution in the RA database.

The total number of training seats, the total supply, and the accession requirements were set to be equal to the gross contract mission. Setting these variables to be equal required adjustments to each of them. First, the gross contract mission was reduced to eliminate prior service accessions and accessions that do not require training. The total supply was adjusted to match this number, keeping the same proportional representation of supply groups that was found in the historical data from FY 2006-08. Second, requirements from the 2009 Target Report dated 7 October 2008 were inflated by estimated DEP losses from the Build-To spreadsheet dated 10 November 2008. Since the spreadsheet did not have good DEP loss estimates for October and November 2008, we estimated a 10% DEP loss rate for these months, which was consistent with our analysis of historical data. The resulting requirements were adjusted again by a single factor to make the total requirements equal to the gross contract mission. Finally, initial fill, taken from the 2009 Target Report dated 7 October 2008, was subtracted from the requirements. Third, total seats, taken from the Build-To spreadsheet, were adjusted using the same procedure that was used for requirements, so that the total number of seats also equaled the gross contract mission.

In general, the number of training seats for the entire fiscal year is not known at the beginning of that year. Consequently, there does not seem to be a good way to get an independent estimate of the number of seats by MOS and month. The procedure that we used ensures that there are sufficient seats to meet training requirements.

Evaluating Impacts of Increasing Number of Motivated 3B Applicants

To evaluate the impact of increasing the number of applicants in TSC 3B, by adding applicants who passed the TOPS screen, we made four runs of the EPAS optimization. The first run used a baseline case reflecting the FY 09 accession requirements and historical supply group distribution. The other runs increased the number in supply groups that included "motivated" TSC 3B applicants by 2,000, 4,000, and 8,000, respectively, while proportionately decreasing the numbers in other supply groups to obtain the same total number of applicants. The objective function for the EPAS optimization was modified to be more descriptive of current selection and classification policies, rather than to maximize predicted performance of the recruit cohort.

Problem Definition

Objective Function

The objective function for the EPAS optimization is shown in Table 4 with line numbers added for ease of reference. The first line defines the objective to be maximized as "MPP" (mean predicted performance) and restricts the calculation to allowable combinations of SG, contract month (CM), accession month (AM), and MOS, as defined in the variable named "SCOPE(i,j,k,m)." The SCOPE variable reflects policy for the delayed entry program (DEP), which differs between seniors and other applicants, in that seniors may remain in the DEP until the end of the school year. It also reflects the fact that AM must be later (i.e., a larger number) than CM, as well as other factors that restrict the allocation of applicants from specific SGs to particular MOS or months. As the code indicates, the overall value of MPP is a sum over all allowable combinations of SG, CM, AM, and MOS.

Table 4. EPAS Objective Function

```
01 MPP := sum(i in SG,j in CM,k in AM,m in MOS|SCOPE(i,j,k,m) = true)
02     VALUE(m,i) * FILL(i,j,k,m) -
03     sum(m in MOS,k in AM)    dACCMSSN(m,k)   *   MOSaccmssnPenalty -
04     sum(m in MOS)            dACCCAT1(m)     *   MOSacccat1Penalty -
05     sum(m in MOS,k in AM)    dACCCAT3(m,k)   *   MOSacccat3Penalty -
06     sum(m in MOS,k in AM)    dACCCAT4(m,k)   *   MOSacccat4Penalty -
07     sum(m in MOS)            dFY1REQ(m)      *   TrainReqPenalty -
08     sum(k in AM)             dAAMMP(k)       *   MonAccPenalty -
09     sum(m in MOS,k in AM)    dSEATS(m,k)     *   MaxSeatsPenalty -
10                              dCAT4           *   CatIVPenalty
```

The second line of the objective function indicates that it considers both the number of applicants from SG_i assigned to MOS_m—i.e., the overall fill of the MOS with applicants from the SG—and the value of assigning an applicant from SG_i to MOS_m. SGs are used in place of individuals in EPAS optimization based on a cost-value function that relates SGs to MOS. In the EPAS Field Test, the value of a specific SG-MOS connection was the average score on the AA composite used by the MOS obtained for the subset of members of the SG who qualified for the MOS. Since the AA composites predict the performance in an MOS, the objective function (thus far) represented the mean predicted performance. The goal of the current application was to reflect current policy rather than to optimize predicted performance. We believe that the goal of current Army policy is to meet accession goals by filling jobs with qualified applicants. We modified the objective function to represent Army policy by defining the value function as the proportion of applicants in SG_i who meet the requirements of MOS_m. We used the RA Analyst database from FY 06-08 to calculate this proportion.

Lines 3 through 10 represent optional penalties to the objective function that are levied when no solution is found that meets all constraints. When the penalty function is activated, the constraint that is not satisfied is relaxed to produce a feasible solution. The extent to which the constraint is relaxed (i.e., the number of applicants that must be added to achieve a feasible solution) is recorded in a corresponding variable beginning with the letter "d" (e.g., dACCMSSN(m,k) is used to record relaxation of the accession mission constraint). The extent to which the constraint is relaxed is then multiplied by the value of the penalty, which is then subtracted from the overall value of the objective function. Setting the penalties to zero and instructing the optimization not to calculate the "d" variables eliminated the penalty in the objective function. The optimizations conducted in the EPAS Field Test did not use any of the penalties in the objective function. We used penalties in this project to ascertain the extent to which constraints were not being met under specified conditions.

Constraints

The EPAS optimizations that we conducted considered the following constraints.

- *Total supply.* Total fill across MOS and accession months cannot exceed total supply for each supply group and contract month (specified in the input file as supply.csv).
- *Seats by MOS and month.* The fill (i.e., number of assignments) to an MOS and training start month cannot exceed the number of seats available for that MOS and month (specified in the input file as clmax.csv).
- *Total accession goals by month.* The total fill in a given accession month must meet or exceed the total accession goal for that month (specified in the input file as aammp.csv).
- *TSC 1-3A requirements by MOS.* The number of assignments of applicants in TSC 1-3A to each MOS must meet or exceed the Soldier TSC 1-3A goals for that MOS (specified in the input file as acccat1.csv).

The first three of these constraints were also used in the EPAS Field Test (Sticha et al., 2007). In addition, the field test included a constraint regarding high-priority MOS, because the ability of EPAS to meet the accession requirements for these MOS was a major concern in the evaluation. In the current project, we are concerned about the ability of the Army to meet MOS Soldier TSC 1-3A requirements with an increased number of TSC 3B applicants. Consequently, we replaced the constraint that addressed the fill for high priority MOS with a constraint regarding Soldier TSC 1-3A goals.

EPAS Runs

We conducted four sets of runs of the EPAS optimization, using the objective function and constraints described previously. The baseline case represented a supply distribution consistent with the distribution of applicants over supply groups for previous years. The test cases added 2,000, 4,000, and 8,000 applicants, respectively, from TSC 3B who passed the TOPS screen, reducing other SGs proportionately to obtain the same total supply. The EPAS run simulates the allocation of gross contracts (i.e. the baseline supply) in meeting FY09 total and MOS accession requirements, while abiding by the training management constraints.

Defining the Baseline Case

The distribution of applicants across SGs was calculated based on historical data from FY 2006-08. This distribution was then applied to obtain a total supply equal to the gross contract mission. Similarly, all other variables were set to estimate the FY 09 situation, as described previously.

Defining the Test Cases

In the test cases, we allocated additional TSC 3B applicants passing the TOPS screen to the appropriate SGs, while reducing other SGs proportionately in order to keep the total supply constant. Other variables retained their values from the baseline case. We illustrate the allocation process for the case in which 8,000 TSC 3B applicants were assessed. To allocate the additional TSC 3B applicants, first we partitioned the total baseline supply into two subsamples, (a) TSC 3Bs passing the TOPS screen and (b) everyone else, and computed the distribution of the SGs within each subsample. The calculations in this step are based on the overall and SG estimates of the number of TSC 3Bs passing the TOPS screen, obtained previously (see page 7). This step produced two sets of 246 (number of SGs) percentages, one for each subsample, each adding to 100%. Second, we increased the total for the subsample of TSC 3Bs passing TOPS by 8,000 from 2,610 to 10,610 and decreased the total for the other subsample by 8,000 from 84,351 to 76,351, thereby keeping the total supply constant. Third, we allocated the adjusted subsample totals to the 246 SGs using the corresponding SG percentage distribution. That is, we multiplied 10,610 by the first set of 246 SG percentages (many of these percentages are zero) for the subsample of TSC 3B applicants passing TOPS, and multiplied 76,351 by the second set of 246 SG percentages for the other subsample. The test case total for each SG was then obtained by adding the allocated numbers for the two subsamples corresponding to the SG. Due to rounding error, the total supply in the test case (86,993) was slightly higher than the total baseline supply (86,961).

Adjusting TSC 1-3A Constraint to Represent Set-Aside

For the test cases, we modified the TSC 1-3A constraint so that the additional TSC 3B applicants were not considered in determining the TSC 1-3A requirement. The additional TSC 3B applicants were removed from the total accessions, and the required percentage of TSC 1-3A applicants was applied to the remaining applicants. We believe that this approach provides a reasonable evaluation of the effect of the additional TSC 3B applicants. It does not assess a penalty for assigning these applicants to an MOS. On the other hand, it does not consider them to be equivalent (in a narrow sense) to TSC 1-3A applicants.

The overall requirement specifies that 60% of accessions should be in TSC 1-3A. However, the specific percentages vary from 40% to 100% across MOS. We used the following procedure to implement the set-aside to establish TSC 1-3A goals for each MOS. First, we computed the overall MOS percentages among the total contract mission. We used these percentages to allocate the additional TSC 3B applicants proportionately across MOS. We then adjusted the TSC 1-3A constraint requirements for each MOS by subtracting the proportional amount and applying the TSC 1-3A percentage for the MOS to this adjusted total.

For example, suppose that the total contract mission is 70,000 and that 700 or 1% of the total mission is for a specific MOS. Furthermore, suppose that 42.9% of the MOS accessions are required to be in TSC 1-3A. That is, 300 of the 700 accessions in the target MOS are required to be in TSC 1-3A. If 8,000 motivated TSC 3B applicants are added to the supply, we assume that they will be distributed proportionately across all MOS. Thus, 1% or 80 of these additional applicants will be allocated to the target MOS, and will be part of the set-aside. Of the remaining 620, 42.9% or 266 would be required to be in TSC 1-3A. Thus, the addition of 8,000 highly motivated TSC 3B applicants reduced the TSC 1-3A requirement for the target MOS from 300 to 266.

Procedure for Running Optimizations

The general strategy for running the EPAS optimizations was to make initial runs using a small number of constraints, and then gradually increase the number of constraints until all five constraints were applied, or until the optimization had no feasible solution. The first run included constraints for total supply and for seats by MOS and month. Subsequent runs added constraints one at a time in the following order: total accessions by month, accession mission by MOS, and TSC 1-3A requirements by MOS. If the addition of a constraint made the problem infeasible, then the penalty variables for that constraint were added to the optimization to determine the extent of the problem. For example, if the addition of the constraint of TSC 1-3A requirements by MOS to the other constraints led to an infeasible solution, then adding the variables dACCCAT1(m) and MOSacccat1Penalty to the problem definition would allow us to determine which MOS could not be filled to the required level with applicants in TSC 1-3A and how big the shortage was by MOS. All optimization runs achieved solutions; consequently, it was not necessary to use any of the penalty functions to estimate the magnitude of shortages.

Optimization Results

Results of EPAS allocations indicate that the number of motivated TSC 3B applicants can be increased up to 8,000, and still meet the overall Army goal of 60% TSC 1-3A, assuming that the additional 3B applicants can be "set-aside" and do not count against the TSC 1-3A requirement. A summary of the FY09 allocations for the base and test cases is shown in Table 5.[4] As a percentage of the adjusted accession mission, the total TSC 1-3A fill increased from 62.7% for the base case to 64.1% for the case with 8,000 additional motivated TSC 3B applicants. Thus all cases met the appropriately adjusted TSC 1-3A requirement. In addition, the allocation with

[4] Total Accession Mission pertains to Non-Prior Service (NPS) Soldiers who require training – so-called NPS trainers. The mission as shown has been adjusted (inflated) for expected DEP and training attrition, and reduced by existing FY09 fill at the starting date of the allocation run.

2,000 additional motivated TSC 3B applicants met the *unadjusted* requirement, and the allocation with 4,000 additional TSC 3Bs nearly met this requirement.

Although the addition of TSC 3B applicants increased the percentage of the adjusted mission that was filled by applicants in TSC 1-3A, the absolute number of applicants in this group decreases as the number of additional TSC 3B applicants increases. Table 6, Table 7, and Table 8 show how this decrease is distributed across MOS for 2,000, 4,000 and 8,000 additional highly motivated TSC 3B applicants, respectively. The distribution is presented as a stem-and-leaf diagram. The MOS are sorted in decreasing order according to the difference between the TSC 1-3A fill in the case with additional TSC 3B applicants and the base case, expressed as a percentage of the TSC 1-3A base case fill for that MOS.

Table 5. Summary Statistics for EPAS Allocation Results

	Base	2,000 TSC 3B	4,000 TSC 3B	8,000 TSC 3B
Total Accession MIssion	70,673	70,673	70,673	70,673
Set-aside for Motivated TSC 3B Applicants	0	2,000	4,000	8,000
Adjusted Accession Mission	70,673	68,673	66,673	62,673
Total TSC 1-3A Requirement	42,670	41,423	40,215	37,806
Percentage TSC 1-3A Requirement	60.4%	60.3%	60.3%	60.3%
Allocation TSC 1-3A Fill	44,346	43,770	42,490	40,202
TSC 1-3A Percentage of Adjusted Mission	62.7%	63.7%	63.7%	64.1%

With 2,000 additional TSC 3B applicants, nearly half of the MOS (63) show a decrease in TSC 1-3A fill between .01% and 9.99% (see Table 6). An additional 35 MOS show no difference in TSC 1-3A fill from the base case. For 15 MOS, the TSC 1-3A fill actually increases with the addition of 2,000 TSC 3B applicants. The increase gets as high as 37%, for the 68Q (Pharmacy Specialist) MOS. A similar distribution with somewhat greater negative differences occurs with the addition of 4,000 TSC 3B applicants (see Table 7). The differences are more extreme with the addition of 8,000 TSC 3B applicants (Table 8), with 73 MOS showing a decrease between 10% and 19.99%. The maximum loss of nearly 42% occurred for the 63A (M1 Abrams Tank System Maintainer) MOS.

The temporal variation in the test score category of accessions depends on the variation in supply over time and on the length of time that applicants can spend in the DEP. Figure 3 shows the percentage of TSC 1-3A applicants in the supply by contract month. This percentage gradually increased from October through August, then decreased substantially in September. As expected, test cases have a lower percentage of TSC 1-3A applicants than the base case. When the maximum time that an applicant may spend in the DEP is short, then accessions by accession month should closely match the supply. A longer DEP limit, such as the 3-5 month limit used in the optimization, provides some flexibility for accessions to differ from the supply population by month.

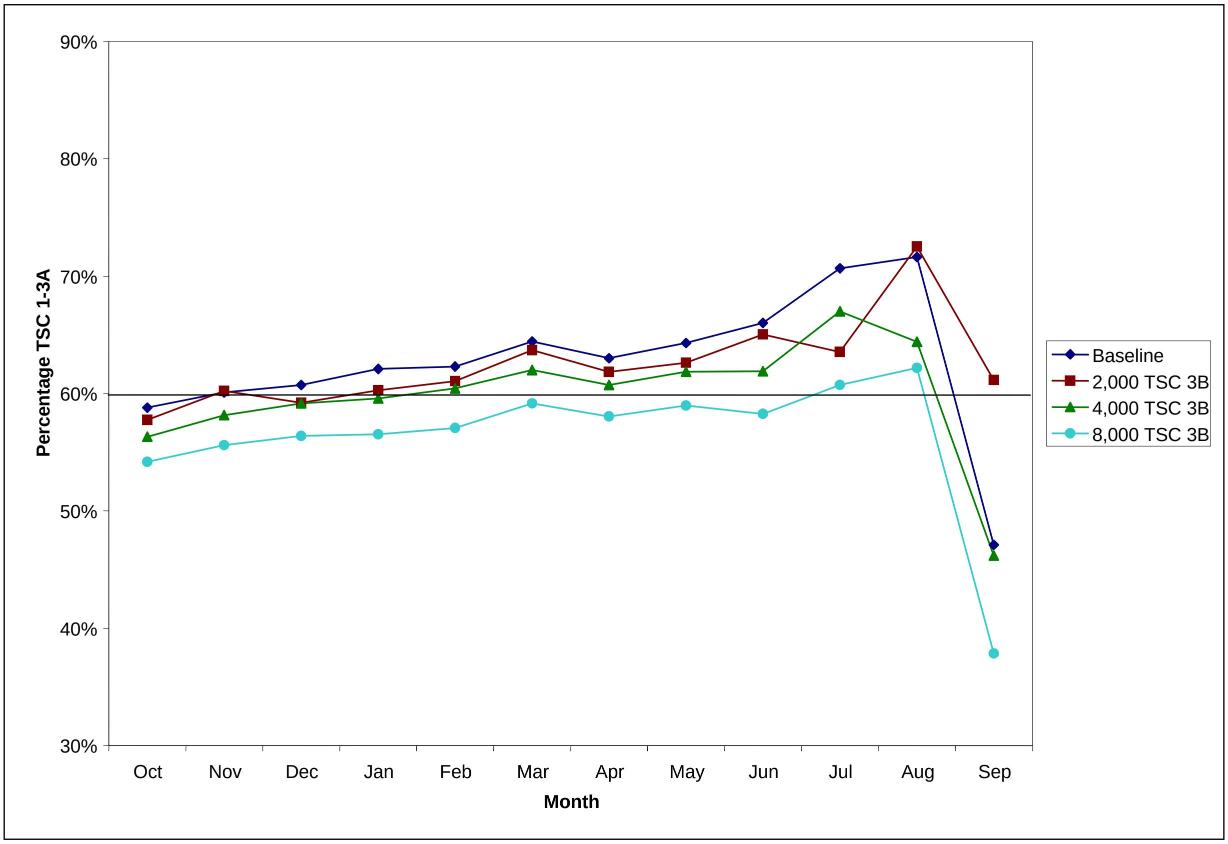

Figure 3. Percentage of TSC 1-3A applicants in supply by contract month.

Table 6. TSC 1-3A Distribution of Difference between Fill in Base Case and with 2,000 Additional TSC 3B Accessions by MOS

		MOS and Difference Measures																					
Range		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
39.99	MOS	68Q																							
>= d >=	Diff	19																							
30.00	% Diff	37.25%																							
29.99	MOS	21Y	45K																						
>= d >=	Diff	48	20																						
20.00	% Diff	23.4%	21.3%																						
19.99	MOS	92Y	15D	37F	63B	35S																			
>= d >=	Diff	61	7	18	140	15																			
10.00	% Diff	15.7%	15.2%	11.2%	10.9%	10.6%																			
9.99	MOS	35F	68S	35H	21T	68T	25B	11X																	
>= d >=	Diff	70	3	9	2	3	4	81																	
0.01	% Diff	9.9%	9.7%	9.4%	6.5%	6.1%	1.1%	1.1%																	
	MOS	14S	68P	27D	25F	25S	15W	94D	21M	21V	45B	21W	94T	68G	94P	18X	21D	35T	46Q						
	Diff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
d = 0	% Diff	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
	MOS	46R	94H	94K	68W	68A	94S	68K	94M	25R	25N	25P	44C	42F	94Y	14J	21K	35G							
	Diff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
	% Diff	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%							
	MOS	21B	94A	35N	88L	31E	52D	25L	15J	14E	13F	42A	92R	19K	68E	92F	19D	88M	92W	21E	89D	13B			
-0.01	Diff	-10	-2	-6	-1	-2	-7	-5	-5	-5	-15	-10	-9	-20	-1	-21	-28	-37	-2	-15	-25	-27			
	% Diff	-0.6%	-1.0%	-1.2%	-1.8%	-1.9%	-2.6%	-2.6%	-2.6%	-2.7%	-2.7%	-2.7%	-2.7%	-2.8%	-2.8%	-2.8%	-2.8%	-2.8%	-2.9%	-2.9%	-2.9%	-2.9%			
	MOS	31B	92A	13D	25U	35M	92G	63M	88H	14T	63H	68R	15P	63J	13R	68M	44B	88K	25C	68D	15R	62B			
>= d >=	Diff	-58	-28	-13	-45	-16	-22	-10	-3	-13	-8	-3	-5	-6	-7	-1	-2	-1	-3	-1	-5	-2			
	% Diff	-2.9%	-2.9%	-2.9%	-2.9%	-2.9%	-3.0%	-3.0%	-3.0%	-3.1%	-3.1%	-3.1%	-3.1%	-3.2%	-3.2%	-3.2%	-3.2%	-3.2%	-3.3%	-3.3%	-3.5%	-3.6%			
	MOS	63D	21C	15Q	52C	15B	15Y	45G	13M	13W	13S	15U	15F	15N	15G	56M	15T	25V	94R	68J	15S	92S			
-9.99	Diff	-2	-4	-4	-4	-5	-4	-3	-3	-1	-1	-8	-3	-2	-5	-2	-18	-2	-1	-1	-4	-2			
	% Diff	-3.6%	-3.6%	-3.7%	-3.7%	-3.7%	-3.8%	-4.0%	-4.2%	-4.5%	-4.5%	-5.1%	-5.1%	-5.1%	-5.6%	-5.7%	-5.7%	-5.9%	-5.9%	-6.3%	-6.9%	-7.7%			
-10.00	MOS	25M	94L	68X	74D	94E	94F	25Q	21R	92M															
>= d >=	Diff	-2	-1	-15	-34	-37	-32	-200	-2	-1															
-19.99	% Diff	-10.0%	-11.1%	-11.4%	-11.4%	-12.2%	-13.6%	-14.2%	-14.3%	-14.3%															
-20.00	MOS	44E	15H	68H	88N	13P																			
>= d >=	Diff	-2	-6	-3	-4	-68																			
-29.99	% Diff	-20.0%	-20.0%	-23.1%	-26.7%	-28.2%																			
-30.00	MOS	63A																							
>= d >=	Diff	-86																							
-39.99	% Diff	-36.2%																							

Table 7. TSC 1-3A Distribution of Difference between Fill in Base Case and with 4,000 Additional TSC 3B Accessions by MOS

		MOS and Difference Measures																							
Range		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
49.99	MOS	14T	42A																						
>= d >=	Diff	188	149																						
40.00	% Diff	44.7%	40.6%																						
39.99	MOS	15R	15S																						
>= d >=	Diff	49	18																						
30.00	% Diff	34.8%	31.0%																						
29.99	MOS	15B																							
>= d >=	Diff	27																							
20.00	% Diff	20.1%																							
19.99	MOS	68R	15J	25C	35S																				
>= d >=	Diff	18	32	11	15																				
10.00	% Diff	18.8%	16.8%	12.0%	10.6%																				
9.99	MOS	68S	15Q	21T	56M	21Y	35N	94A																	
>= d >=	Diff	3	10	2	2	11	24	4																	
0.01	% Diff	9.7%	9.3%	6.5%	6.0%	5.4%	4.6%	1.9%																	
	MOS	94E	14J	94K	25S	68P	21V	94T	68G	94P	18X	21D	35T	46Q	46R	94H									
	Diff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									
d = 0	% Diff	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%									
	MOS	68W	68A	94S	68K	94M	25R	25N	44C	94Y	68H	25P	27D	35G	25F	42F									
	Diff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									
	% Diff	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%									
	MOS	13P	21K	21W	45B	21B	14S	31E	44B	37F	94F	25L	35H	14E	92Y	88L	52D	92R	68E	92F	19D	13F	25B		
-0.01	Diff	-6	-1	-1	-1	-69	-2	-5	-3	-8	-12	-10	-5	-10	-21	-3	-15	-18	-2	-42	-56	-31	-20		
	% Diff	-2.5%	-2.5%	-2.9%	-3.0%	-3.8%	-4.3%	-4.7%	-4.8%	-5.0%	-5.1%	-5.2%	-5.2%	-5.4%	-5.4%	-5.5%	-5.5%	-5.5%	-5.6%	-5.6%	-5.6%	-5.6%	-5.6%		
	MOS	63B	35M	35F	15P	31B	88M	25U	19K	92W	21E	89D	63M	13B	92A	92G	63J	13D	63H	68Q	94R	13R	88H		
>= d >=	Diff	-72	-31	-40	-9	-114	-75	-88	-41	-4	-30	-50	-19	-54	-56	-43	-11	-26	-15	-3	-1	-13	-6		
	% Diff	-5.6%	-5.7%	-5.7%	-5.7%	-5.7%	-5.7%	-5.7%	-5.7%	-5.7%	-5.7%	-5.7%	-5.8%	-5.8%	-5.8%	-5.8%	-5.8%	-5.8%	-5.9%	-5.9%	-5.9%	-6.0%	-6.1%		
	MOS	68J	21C	45K	68M	88K	52C	15D	15Y	68D	45G	13M	62B	63D	15N	15G	15U	15F	15T	25V	13S	13W	11X		
-9.99	Diff	-1	-7	-6	-2	-2	-7	-3	-7	-2	-5	-5	-4	-4	-3	-7	-13	-5	-27	-3	-2	-2	-729		
	% Diff	-6.3%	-6.4%	-6.4%	-6.5%	-6.5%	-6.5%	-6.5%	-6.6%	-6.7%	-6.7%	-7.0%	-7.1%	-7.1%	-7.7%	-7.9%	-8.2%	-8.5%	-8.6%	-8.8%	-9.1%	-9.1%	-9.9%		
-10.00	MOS	25M	21M	94L	92S	94D	74D	15W	92M	68X	25Q														
>= d >=	Diff	-2	-1	-1	-3	-2	-41	-8	-1	-19	-233														
-19.99	% Diff	-10.0%	-11.1%	-11.1%	-11.5%	-12.5%	-13.7%	-14.0%	-14.3%	-14.4%	-16.6%														
-20.00	MOS	44E	21R	15H	88N																				
>= d >=	Diff	-2	-3	-7	-4																				
-29.99	% Diff	-20.0%	-21.4%	-23.3%	-26.7%																				
-30.00	MOS	68T	63A																						
>= d >=	Diff	-15	-90																						
-39.99	% Diff	-33.3%	-37.8%																						

Table 8. TSC 1-3A Distribution of Difference between Fill in Base Case and with 8,000 Additional TSC 3B Accessions by MOS

		MOS and Difference Measures																								
Range		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
19.99	MOS	37F	94L	68D																						
>= d >=	Diff	18	1	3																						
10.00	% Diff	11.2%	11.1%	10.0%																						
9.99	MOS	35H	15Q	13D	35N	35S	88K																			
>= d >=	Diff	9	10	30	28	5	1																			
0.01	% Diff	9.4%	9.3%	6.7%	5.4%	3.5%	3.2%																			
	MOS	25N	25S	94K	68P	94T	68G	94P	18X	21D	35T	46Q	46R	94H	68W											
	Diff	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
d = 0	% Diff	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%											
	MOS	68A	94S	68K	94M	25R	94Y	25P	27D	42F	88N	44C	68X	25F	14J											
	Diff	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
	% Diff	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%											
-0.01	MOS	15H	92A	35F	35G	25Q	15T	94E	21W	14S	45B	68S														
>= d >=	Diff	-1	-36	-30	-9	-80	-22	-25	-3	-4	-3	-3														
-9.99	% Diff	-3.3%	-3.7%	-4.2%	-5.1%	-5.7%	-7.0%	-8.2%	-8.6%	-8.7%	-9.1%	-9.7%														
	MOS	21K	31E	14E	25L	88L	52D	21V	21M	92Y	68E	94A	13F	42A	19K	63B	19D	92F	92R	88M	44B	21E	35M	15P	63H	31B
-10.00	Diff	-4	-11	-20	-21	-6	-30	-1	-1	-43	-4	-23	-62	-41	-81	-144	-113	-85	-37	-149	-7	-59	-62	-18	-29	-228
	% Diff	-10.0%	-10.4%	-10.8%	-10.9%	-10.9%	-10.9%	-11.1%	-11.1%	-11.1%	-11.1%	-11.2%	-11.2%	-11.2%	-11.3%	-11.3%	-11.3%	-11.3%	-11.3%	-11.3%	-11.3%	-11.3%	-11.3%	-11.3%	-11.3%	-11.3%
	MOS	89D	25U	13B	92W	92G	25B	68R	13R	63M	15J	63J	14T	68Q	94R	21C	25C	52C	15R	88H	15Y	68J	62B	63D	13M	
>= d >=	Diff	-99	-176	-107	-8	-85	-41	-11	-25	-38	-22	-22	-49	-6	-2	-13	-11	-13	-17	-12	-13	-2	-7	-7	-9	
	% Diff	-11.4%	-11.4%	-11.4%	-11.4%	-11.4%	-11.5%	-11.5%	-11.5%	-11.5%	-11.6%	-11.6%	-11.6%	-11.8%	-11.8%	-11.8%	-12.0%	-12.0%	-12.1%	-12.1%	-12.3%	-12.5%	-12.5%	-12.5%	-12.7%	
	MOS	15B	45K	15N	21T	68M	15D	11X	15U	45G	15G	15F	13S	13W	56M	92M	25V	25M	92S	15S	94F	94D	74D	15W	21Y	
-19.99	Diff	-17	-12	-5	-4	-4	-6	-973	-21	-10	-12	-8	-3	-3	-5	-1	-5	-3	-4	-9	-39	-3	-57	-11	-40	
	% Diff	-12.7%	-12.8%	-12.8%	-12.9%	-12.9%	-13.0%	-13.2%	-13.3%	-13.3%	-13.5%	-13.6%	-13.6%	-13.6%	-14.3%	-14.3%	-14.7%	-15.0%	-15.4%	-15.5%	-16.3%	-18.8%	-19.1%	-19.3%	-19.4%	
-20.00	MOS	44E	21R	68T	21B																					
>= d >=	Diff	-2	-3	-10	-504																					
-29.99	% Diff	-20.0%	-21.4%	-22.2%	-28.0%																					
-30.00	MOS	68H	13P																							
>= d >=	Diff	-4	-83																							
-39.99	% Diff	-30.8%	-34.4%																							
-40.00	MOS	63A																								
>= d >=	Diff	-99																								
-49.99	% Diff	-41.7%																								

Figure 4 shows the TSC 1-3A fill percentage by accession month. Except for October, in which accessions were high, the pattern in accessions matched the characteristics of the supply population. That is, accessions are relatively low in November, increase to a local high sometime in the summer, and decrease again in September. The difference between the two figures in October probably reflects the training seats that were available for that month. Examination of the available training seats indicated that certain high-density MOS with relatively low cut scores (e.g., 11X, 13B) were filled in October, while other MOS with higher requirements (e.g., 25P, 35Q) still had seats available for that month.

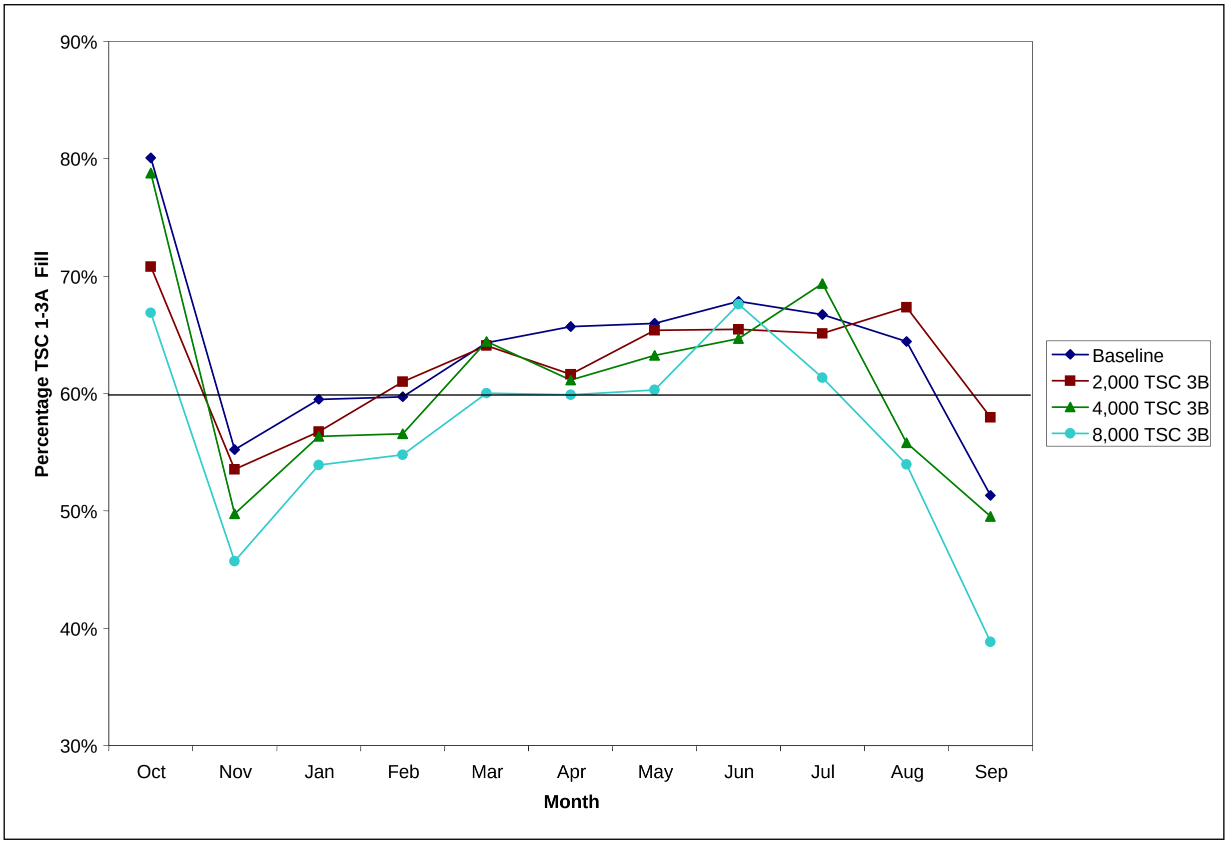

Figure 4. TSC 1-3A fill percentage by accession month

Figure 5 shows the cumulative TSC 1-3A fill by accession month. Here it is clear that the overall proportion of TSC 1-3A accessions increases steadily from November through July or August (depending on the case).

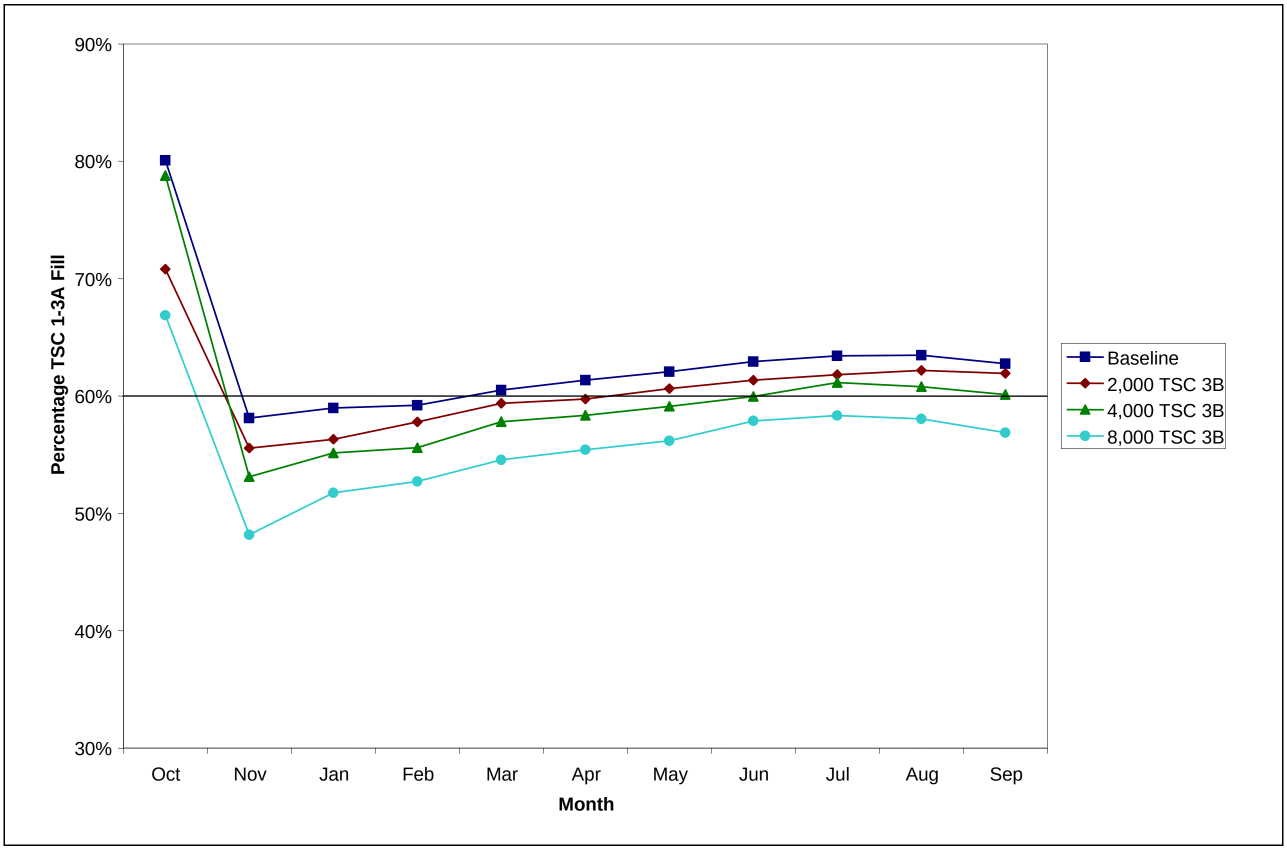

Figure 5. Cumulative TSC 1-3A fill percentage by accession month.

Discussion and Conclusions

Using the EPAS model, as we have modified it, as a description of the classification process, we have been able to make predictions regarding the effect of the addition of up to 8,000 applicants in TSC 3B (who passed the TOPS screen) on the ability of the Army to meet Soldier TSC 1-3A goals. Our simulations assume that the additional applicants are set aside, and that the TSC 1-3A goal percentages apply to the remaining applicants. With this assumption, the results of the simulations showed that the Army was able to meet its TSC 1-3A goals in all test conditions. However, many of the individual MOS would see reductions in the proportion of TSC 1-3A accessions as the number of additional TSC 3B applicants increased.

The addition of 8,000 TSC 3B applicants represents a substantial change to the SG distribution. Although this change was judged to be realistic under some circumstances, it is near the upper limit of what would be expected in practice. Thus, the result that Army TSC 1-3A goals, adjusted to set aside the additional TSC 3B applicants, can be met with this large addition indicates the robustness of the finding across most realistic situations, given supply characteristics similar to those that occurred in the difficult recruiting years of FY 2006-2008.

EPAS was developed as a tool to prescribe the optimal allocation of applicants to MOS (i.e., person-job match) but the results of this effort show that it can be used as a descriptive model as well. Use of EPAS to describe the current allocation process was facilitated by the revisions that were made to the definition of SGs and to the objective function.

Previous versions of EPAS used SGs that identified applicants with similar patterns of aptitudes, as measured by the ASVAB subtests. Although this method of clustering provided some degree of homogeneity within SGs, it did not guarantee that members of the same SG qualified for the same MOS. Since EPAS uses SGs as a surrogate for individuals in the assignment process, homogeneity with respect to MOS eligibility increases the utility of the optimization, both as a prescriptive and a descriptive tool. The revised clustering explicitly considers both MOS eligibility and ASVAB subtest scores in specifying the similarity between applicants, thus increasing the homogeneity for MOS eligibility over the previous methods that considered ASVAB subtest scores alone.

To reflect the primary goals of the Army to fill jobs with qualified recruits and to fill near-term training seats, we modified the objective function to reflect the likelihood that members of an SG qualify for an MOS, rather than their predicted performance in the MOS. Since the SGs are relatively homogeneous with respect to MOS eligibility, the likelihoods were near 0.0 or 1.0 for most SG-MOS combinations. We did not make any changes to increase the focus on filling near-term training seats. However, the DEP policy that was simulated did provide somewhat of a near-term focus by forcing applicants in TSC 1-3A to choose accession dates within 5 months of their contract date, while other applicants (except for seniors) were restricted to spend less than 3 months in the DEP. Restricting the DEP policy further could increase the focus on meeting immediate training needs, at the likely cost of making it more difficult to meet Soldier TSC 1-3A goals.

The changes made to the SG structure and to the EPAS objective function arguably increased the extent to which the optimization results reflect current Army training management policy. However, we did not validate the accuracy of EPAS as a descriptive model. Such a validation would require us to compare the EPAS allocation to the actual job choices of a cohort of recruits.[5] While performing such a validation would provide a good test of EPAS as a predictive model, it was not part of the current effort. In its favor, the EPAS model has been designed to capture the interactions of the major elements in the classification process: the number and composition of expected applicants, available MOS training seats, MOS fill requirements and TSC 1-3A accession goals, delayed entry program policy and overall accession requirements.

Using EPAS as a descriptive model has provided insight into the potential effects of the EEEM initiative on the MOS test score category distribution of a recruit cohort. We believe that such simulations offer the additional ability to manage applicant flow to mitigate the effects of these and other changes in recruit potential. Indeed, the fact that there were some MOS for which the allocation exceeded Soldier TSC 1-3A requirements indicates that there is a benefit to be gained from enhanced management of applicant flow over time. EPAS could support this

[5] The validation would examine such issues as whether members of SGs chose MOS in the same distribution as they were allocated by EPAS, whether the distribution of time between contract date and accession date was similar to the EPAS allocations, and whether the overall distribution of Soldier aptitude was accurately reflected in the EPAS predictions.

management process by providing a way to determine the extent to which the class schedule matches the expected flow of applicants by SG. Of course, it is not possible to predict the SG distribution in detail with high accuracy. Nevertheless, it may be possible to run EPAS multiple times with different supply assumptions, in order to develop and test flexible scheduling strategies. In addition, when a problem meeting Soldier TSC 1-3A goals seems imminent, it may be possible to develop a strategy to minimize the deficit with the aid of EPAS simulations.

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Appendix A
Restoration / Specifications for EPAS Server

EPAS Server

At the beginning of the project, the EPAS server, which had been used for the field test (Sticha, Diaz, Greenston, McWhite, 2007), did not run because of problems with the primary system disk drive. Our first activities for this project were to procure a replacement to the server and to recover the information that was contained in the original server.

Procurement of a New Server

We reviewed the capabilities of the original EPAS server, as well as the requirements for the anticipated data downloads and the Oracle and Xpress-MP software, to establish the hardware requirements for the new server. Based on these requirements, we purchased a Dell Power Edge T605 (early 2009) that contains a 2.0-GHz quad-core Opteron processor, 4 GB of RAM, three 160 GB serial ATA hard drives, and a redundant power supply.

We installed Oracle and Xpress-MP on the new EPAS server, and began to structure a new database based on the documentation for the EPAS system (Smith & Sticha, 2008). Because of the difficulties recovering the data from the original EPAS server, we did not re-populate the database with past data. However, we did re-establish the daily downloads of Recruit Quota System (REQUEST) data from the Keyview system.

Recovery of Data from the Original Server

Data on the original EPAS server were contained on two physical Redundant Array of Independent Disks (RAID) arrays. The internal array contained the operating system, programs, and parts of the database. The external array contained backups of the database and the downloaded REQUEST data. Our procedure for transferring data was designed to minimize the risk of losing the data contained on the external array. Thus, we first tried to use the inherent capability of RAID to recover information from a partially damaged array. Since the operating system was damaged, it was necessary to reinstall Windows, which precluded recovery of information from the internal array. When several attempts to recover the information from the external array failed, we sent the drives from that array to a commercial data recovery lab. The lab was able to recover all critical files from the external array.

Since most of the recovered files were part of an Oracle database, extracting the information from them required that the database be read by Oracle. Unfortunately, the database was corrupted, so that Oracle was not able to open it. After several attempts to restore the database, we used a service that provides data unloading by data extraction (DUDE) as a method to obtain the information contained in the corrupted Oracle databases. Use of this method allowed us to extract previous REQUEST data downloads and the most recent version of the EPAS optimization program source code. The extracted information was archived, but the database was not reconstructed, because reconstruction was not required to meet the objectives of this project. However, the data are available for later use.

Restoration of EPAS Optimization

We installed Release 2008 of Xpress-MP and attempted to run the EPAS optimization. Several minor changes were necessary to meet the requirements of the newer version of the Xpress-MP software. However, when these changes were made, the optimization program appeared to operate correctly. We tested the optimization to determine that it produced an optimal solution when given the input files that were used for the EPAS field test. We also verified that the solution produced by the optimization changed in the expected directions when constraints were added or removed.

Appendix B
EPAS Model Input Files

Table 2A. Input Files Representing Indexes Used by the EPAS Optimization

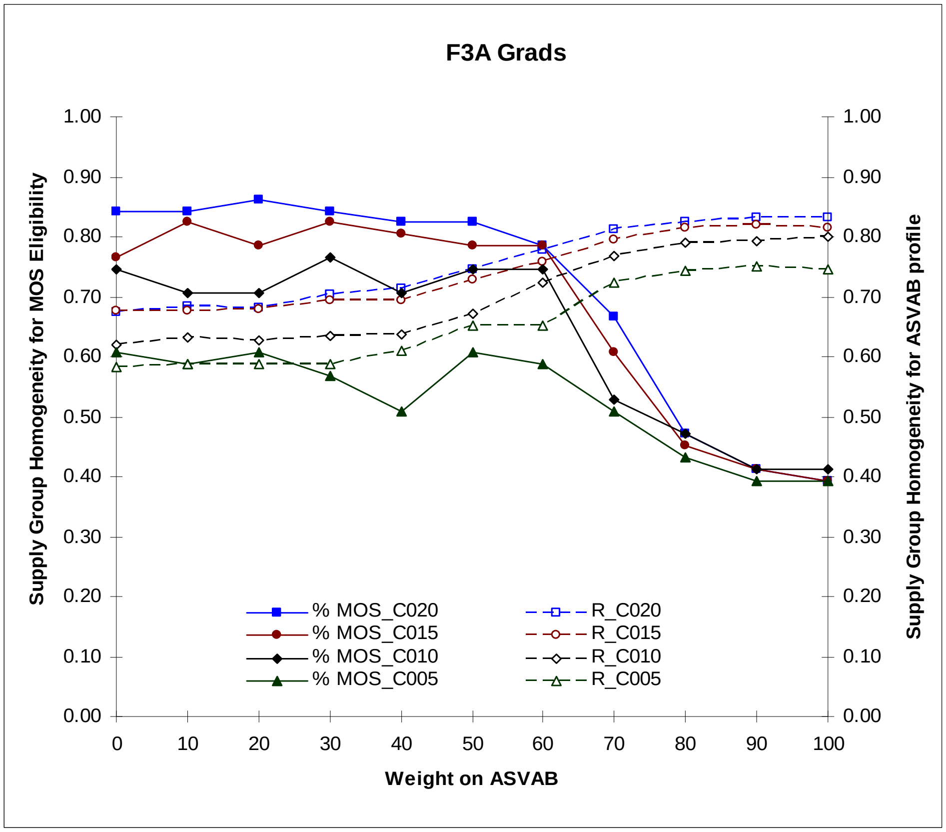
File Name	Description	Source
ait_index.csv	Names of the MOS using Advanced Individual Training(AIT)	EPAS Field Test input file
amfy1a_index.csv	Accession months before date of analysis	EPAS Field Test input file
amfy1b_index.csv	Accession months after date of analysis	EPAS Field Test input file
amfy1_index.csv	Names of the accession months in the first fiscal year of the analysis	EPAS Field Test input file
amfy2_index.csv	Names of the accession months in the second fiscal year of the analysis	EPAS Field Test input file
am_index.csv	List of all accession month names in the analysis	EPAS Field Test input file
cmfy1_index.csv	Names of contract months in the first fiscal year of the analysis	EPAS Field Test input file
cmfy2_index.csv	Names of contract months in the second fiscal year of the analysis	EPAS Field Test input file
cm_index.csv	List of all contract month names	EPAS Field Test input file
mos_index.csv	List of MOS names	MOS Aptitude Area cut scores
osut_index.csv	Names of the MOS using One Station Unit Training (OSUT)	EPAS Field Test input file
prioritymos_index.csv	A list of priority MOS names	EPAS Field Test input file
sg_index.csv	A list of supply group (SG) names	Generated from SG cluster analysis
tsc_index.csv	A list of aptitude category group names	EPAS Field Test input file

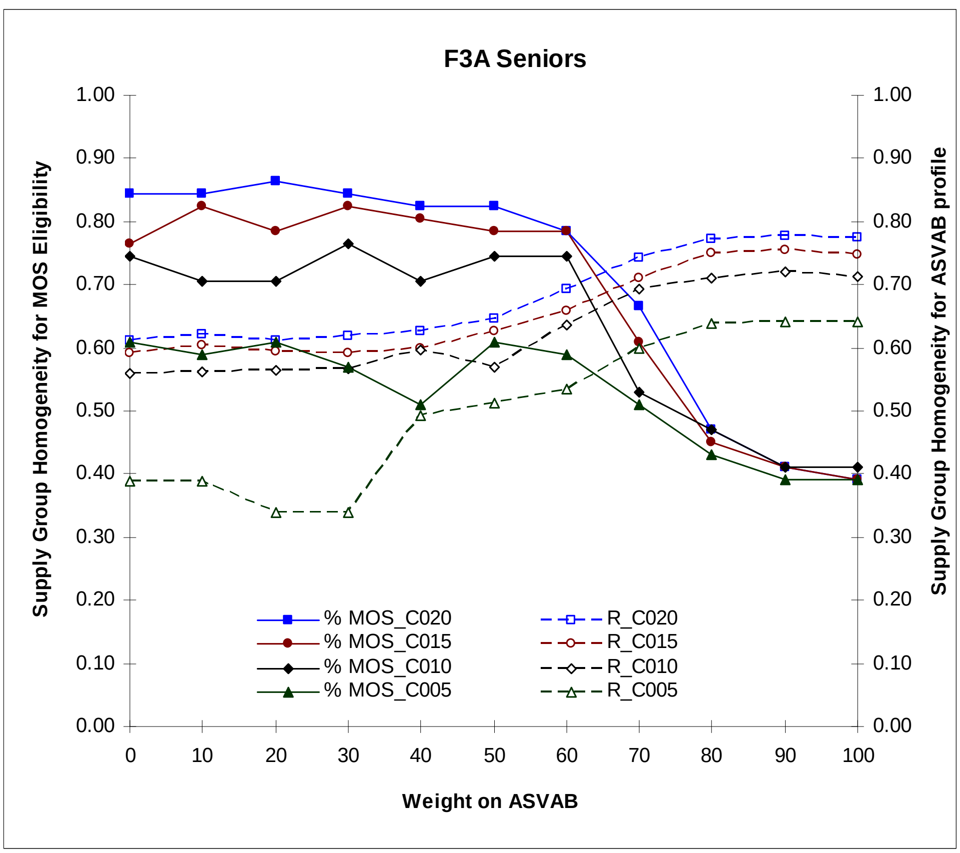
Table 3A. Input Files Representing Requirements, Constraints, and Values Used by the EPAS Optimization

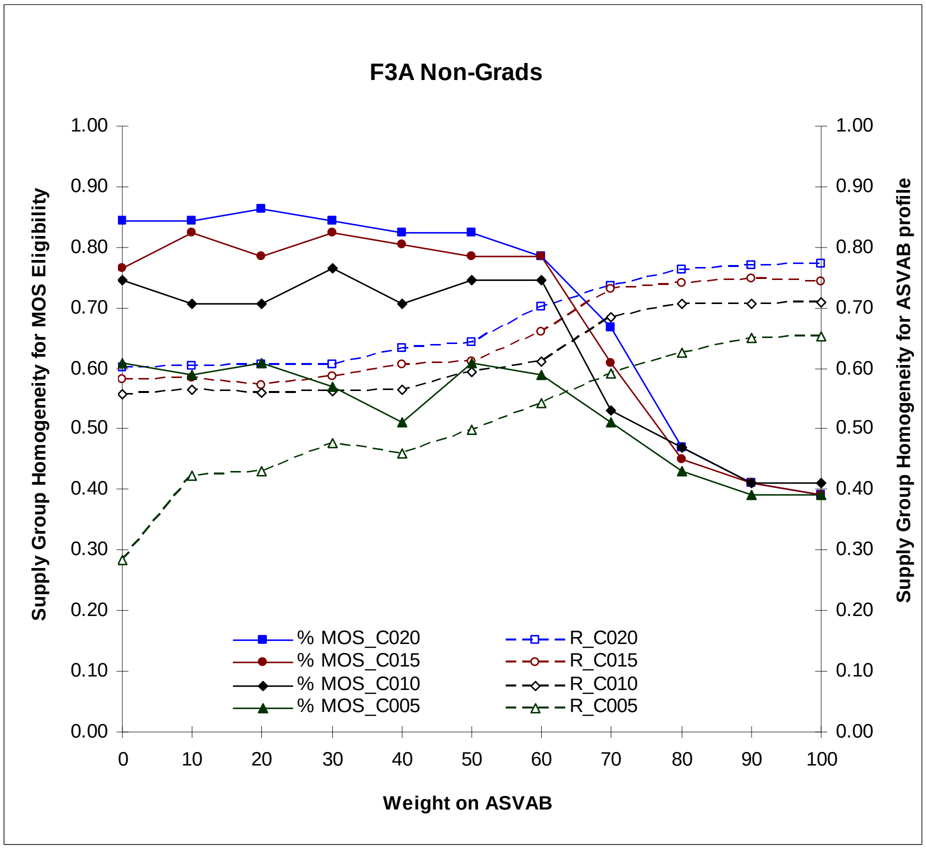
File Name	Description	Source
aammp.csv	Required accessions by accession month	NPS Trainer Accession Goals by month were obtained from the DMPM Memorandum. DEP loss adjustment taken from the Build-To spreadsheet, with a second proportional adjustment to match the gross contract mission. Initial fill, taken from the 7 October 2008 version of the FY2009 Target Report.
accmssn.csv	Monthly accession mission for FY1 by MOS	Monthly accession goals by MOS were obtained from the 7 October 2008 version of the FY2009 Target Report. The goals were reduced by initial fill from the same report, and adjusted so that the totals match the gross contract mission, using the same adjustment factors as used for aammp.csv. Variable not used by optimization.
acccat1.csv	Accessions in TSC I-3A.	Taken from FY 09 Soldier TSC 1-3A goals, adjusted to represent gross contracts.
acccat4.csv	Accessions in TSC 4 by accession month	From FY 09 Soldier TSC 1-3A goals, adjusted to represent gross contracts. Variable not used.
acccat3.csv	Accessions in TSC 3B by accession month	From FY 09 Soldier TSC 1-3A goals, adjusted to represent gross contracts. Variable not used.
actualacc.csv	Reservations made for months before the analysis date	Reservations were incorporated into the initial requirements, so this variable was not used.
clmax.csv	Available seats by MOS and accession month	Seats were set to be equal to accmssn.csv.
dephash.csv	List of allowed combinations of contract month and accession month by supply group.	DEP policy for the analysis was the same as in the EPAS Field Test. This policy was applied to the new supply groups.
futureacc.csv	Reservations made for months after the analysis date	EPAS Field Test input file. Information in this file was not used by the optimization.
fy1req.csv	Total training requirements for first fiscal year by MOS	EPAS Field Test input file. Information in this file was not used by the optimization.
icat4.csv	Indicates supply groups representing TSC 4	Based on SG macro cluster characteristics.
ieducation.csv	Indicates education level of each supply group	Based on SG macro cluster characteristics.
iqual.csv	Indicates supply groups representing high-aptitude applicants	Based on SG macro cluster characteristics.
isex.csv	Table indicates the gender of the member of each supply group	Based on SG macro cluster characteristics.
lmts_afqtiv.csv	Scalar indicating limits on accessions in TSC 4	EPAS Field Test input file
prioritymos_fill.csv	Fill by month for priority MOS	EPAS Field Test input file. Variable not used.
supply.csv	Supply by supply group and contract month.	SG proportions were based on analysis of RA database.
targetmos.csv	MOS with indicator of Target MOS	EPAS Field Test input file. Variable not used.
top25mos.csv	MOS with indicator of Top 25 MOS	EPAS Field Test input file. This constraint was not used in the analysis. Variable not used.
value_table.csv	Value of assigning supply group to MOS	Value was set to the qualification probability, based on the MOS requirements, and the SG aptitude distribution in the RA database.

Appendix C
Plots of ASVAB Score and MOS Eligibility for Each Macro Cluster

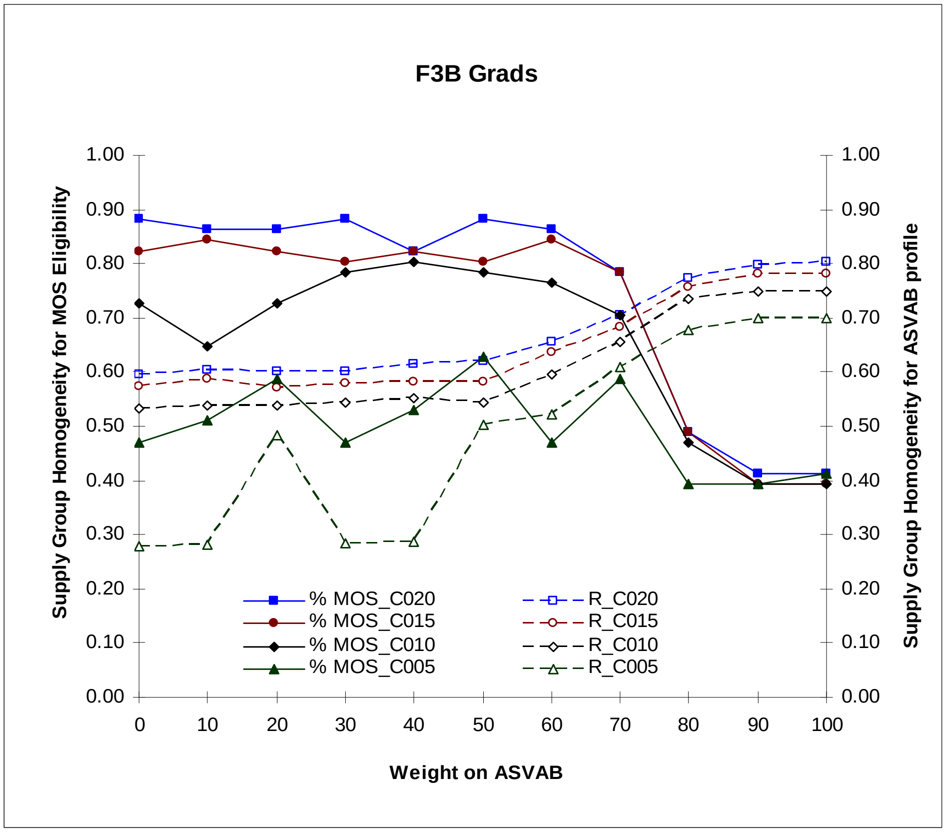
Plots for male and female high school graduates in TSC 1-3A, 3B, and 4 are shown (e.g. F3A Grads depicts high school graduate, female, TSC 1-3A). Group homogeneity for MOS eligibility is shown with solid lines on the plot, while group homogeneity for ASVAB profile is shown with dotted lines. The individual lines represent solutions with more or fewer clusters. The lines labeled “C010” in the legend represent the baseline number of clusters for that macro cluster. Lines labeled “C005” represent a cluster solution with 50% as many clusters as the baseline, while lines labeled “C015” and “C020” represent 50% and 100% more clusters, respectively, compared to the baseline.

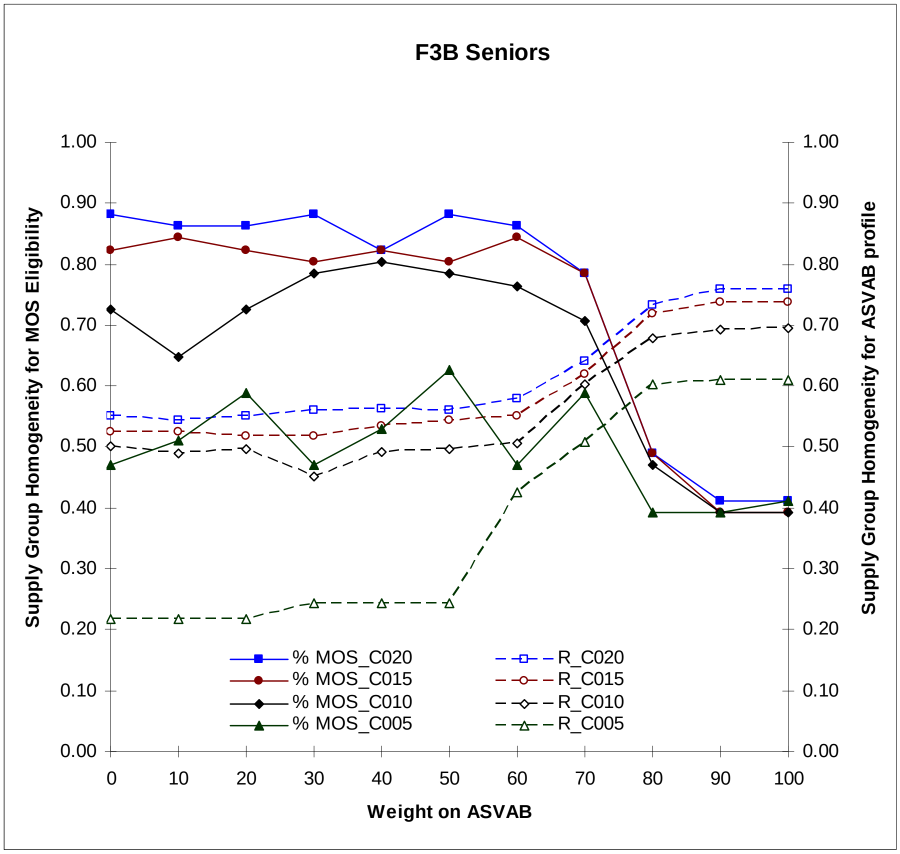

F3A Grads
Supply Group Homogeneity for MOS Eligibility
Supply Group Homogeneity for ASVAB profile
Weight on ASVAB
% MOS_C020
% MOS_C015
% MOS_C010
% MOS_C005
R_C020
R_C015
R_C010
R_C005

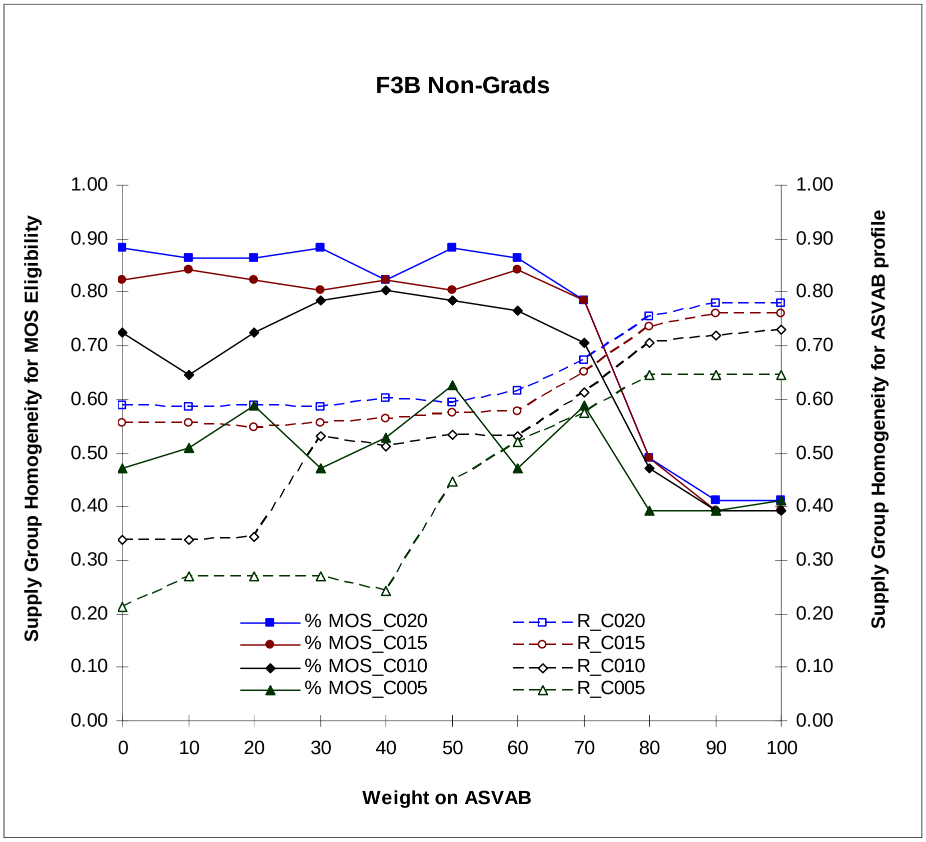

F3A Seniors
Supply Group Homogeneity for MOS Eligibility
Supply Group Homogeneity for ASVAB profile
Weight on ASVAB
% MOS_C020
% MOS_C015
% MOS_C010
% MOS_C005
R_C020
R_C015
R_C010
R_C005

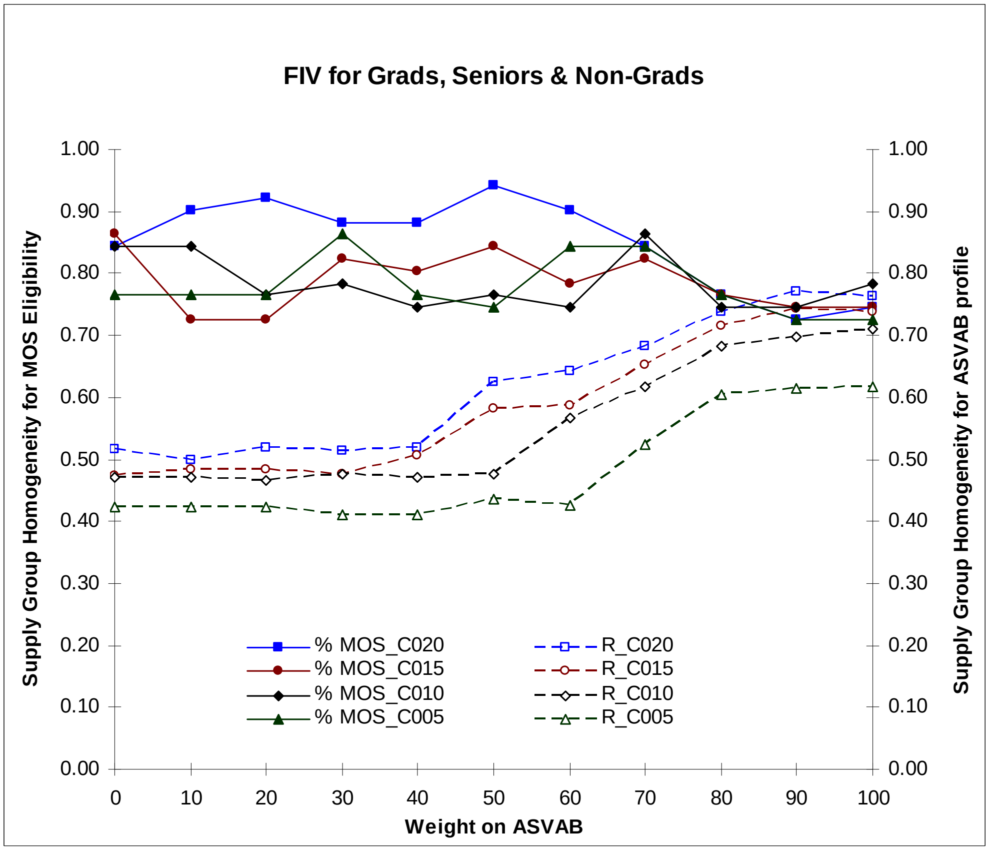


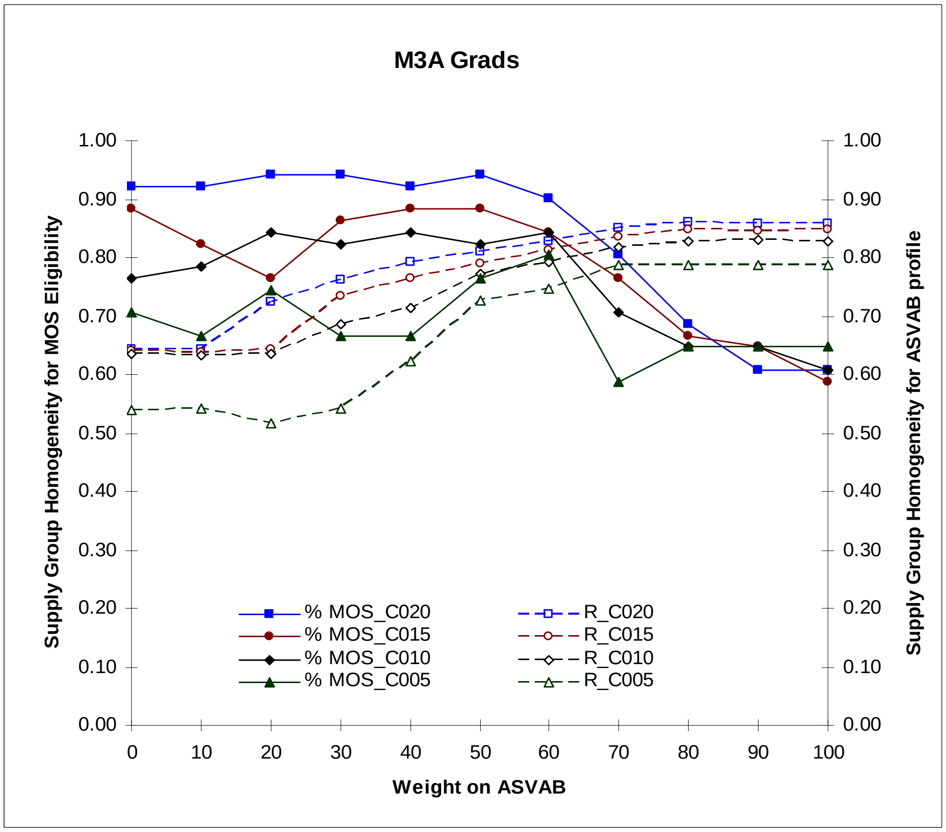
F3A Non-Grads
Supply Group Homogeneity for MOS Eligibility
Supply Group Homogeneity for ASVAB profile
Weight on ASVAB
% MOS_C020
% MOS_C015
% MOS_C010
% MOS_C005
R_C020
R_C015
R_C010
R_C005


F3B Grads
Supply Group Homogeneity for MOS Eligibility
Supply Group Homogeneity for ASVAB profile
Weight on ASVAB
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
10
20
30
40
50
60
70
80
90
100
% MOS_C020
% MOS_C015
% MOS_C010
% MOS_C005
R_C020
R_C015
R_C010
R_C005

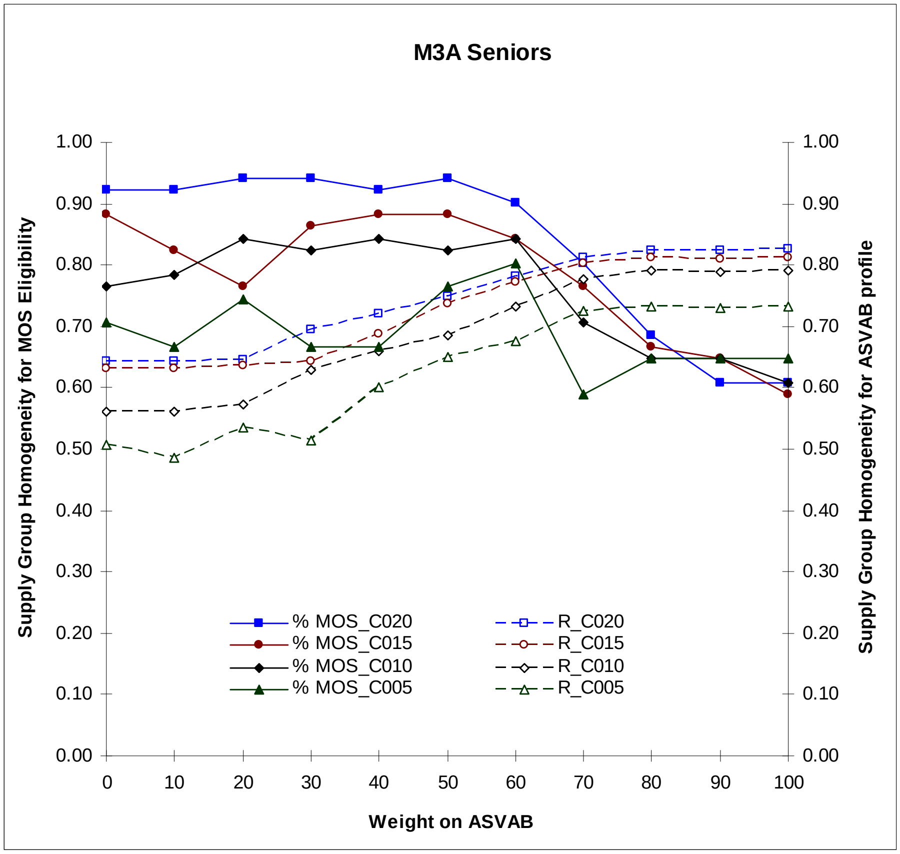

F3B Seniors
Supply Group Homogeneity for MOS Eligibility
Supply Group Homogeneity for ASVAB profile
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
10
20
30
40
50
60
70
80
90
100
Weight on ASVAB
% MOS_C020
% MOS_C015
% MOS_C010
% MOS_C005
R_C020
R_C015
R_C010
R_C005

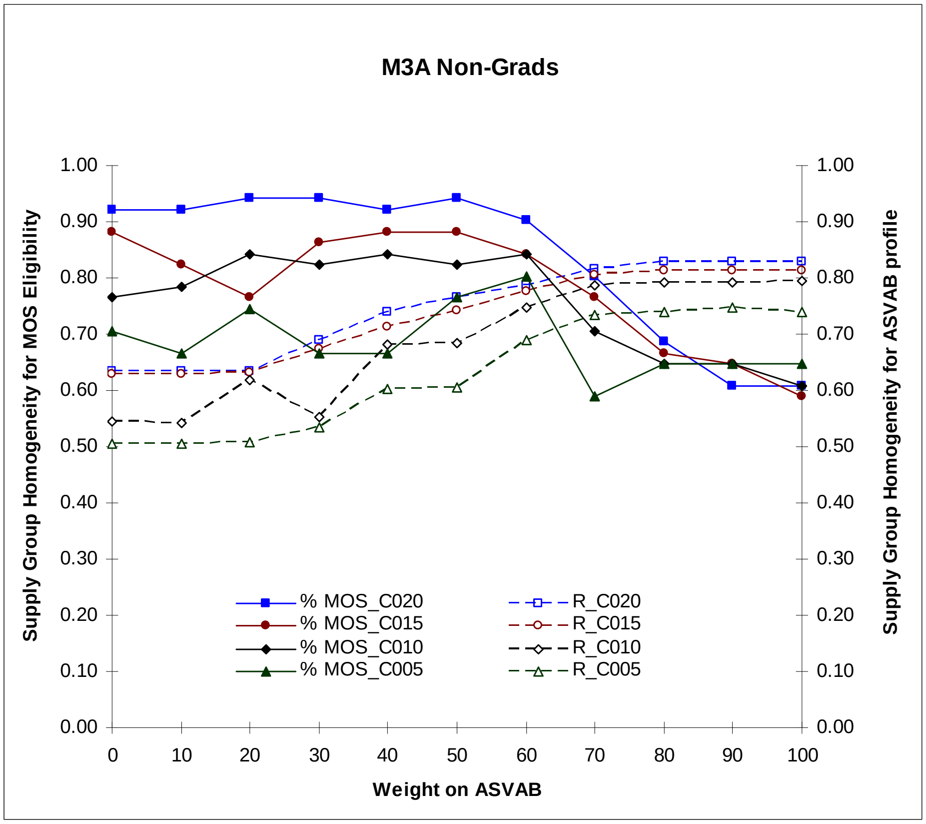

F3B Non-Grads
Supply Group Homogeneity for MOS Eligibility
Supply Group Homogeneity for ASVAB profile
Weight on ASVAB
% MOS_C020
% MOS_C015
% MOS_C010
% MOS_C005
R_C020
R_C015
R_C010
R_C005

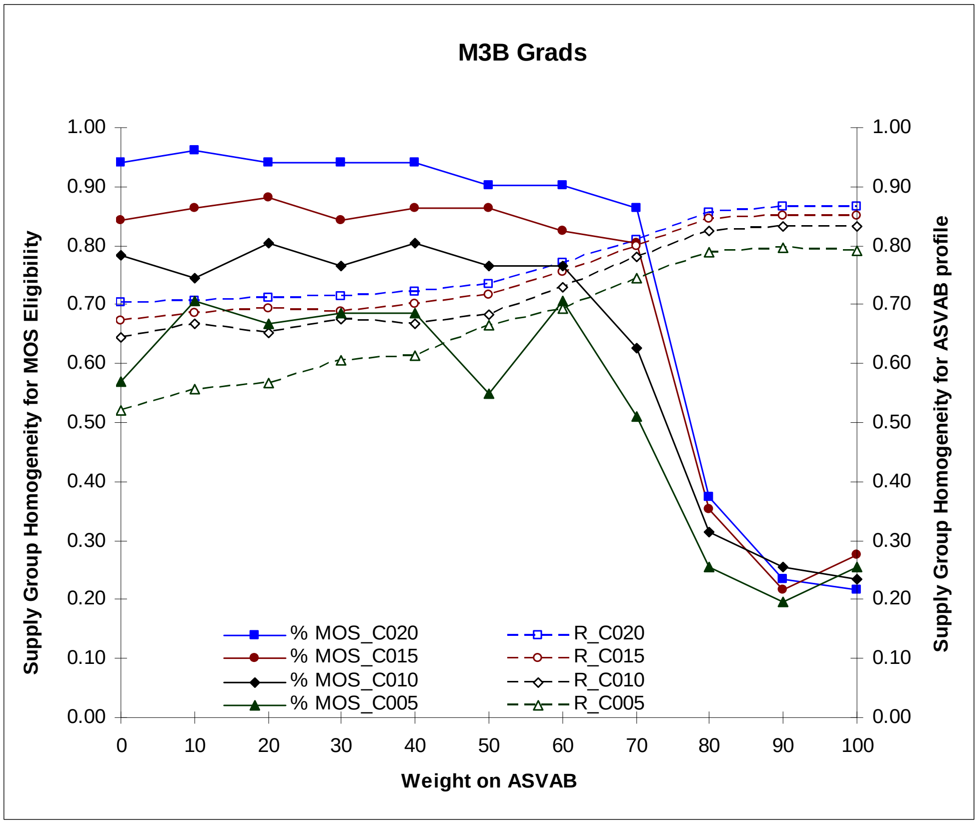

FIV for Grads, Seniors & Non-Grads
Supply Group Homogeneity for MOS Eligibility
Supply Group Homogeneity for ASVAB profile
Weight on ASVAB
% MOS_C020
% MOS_C015
% MOS_C010
% MOS_C005
R_C020
R_C015
R_C010
R_C005



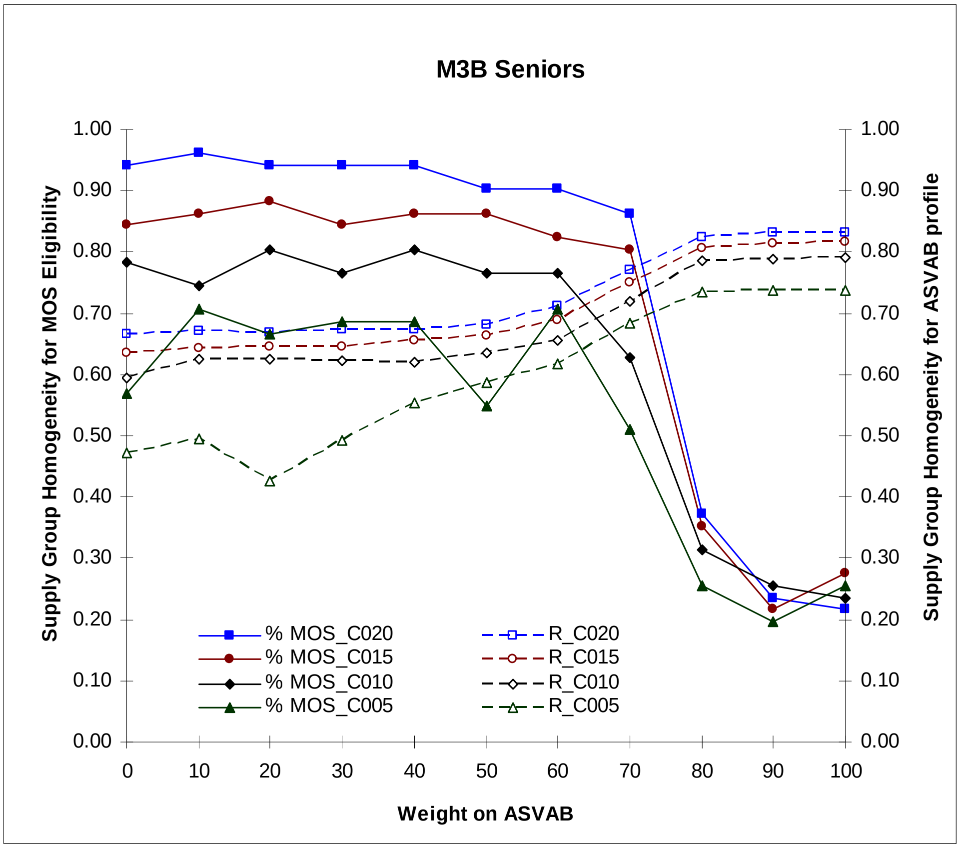
M3A Grads
Supply Group Homogeneity for MOS Eligibility
Supply Group Homogeneity for ASVAB profile
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
% MOS_C020
% MOS_C015
% MOS_C010
% MOS_C005
R_C020
R_C015
R_C010
R_C005
0
10
20
30
40
50
60
70
80
90
100
Weight on ASVAB


M3A Seniors
Supply Group Homogeneity for MOS Eligibility
Supply Group Homogeneity for ASVAB profile
Weight on ASVAB
% MOS_C020
% MOS_C015
% MOS_C010
% MOS_C005
R_C020
R_C015
R_C010
R_C005

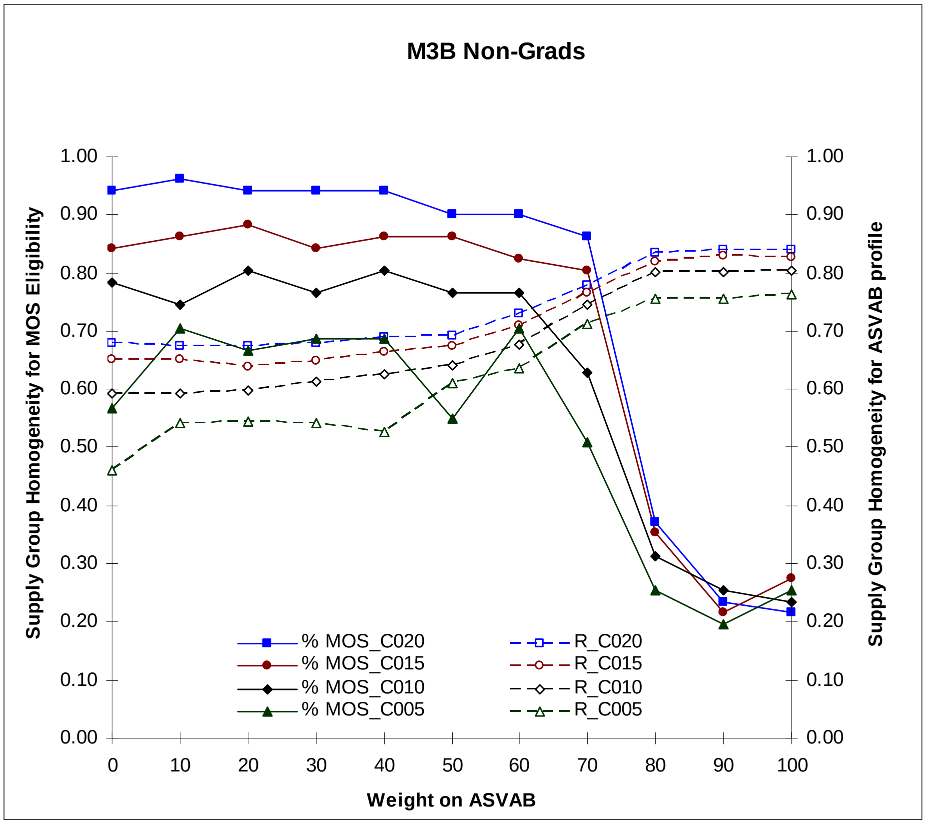

M3A Non-Grads
Supply Group Homogeneity for MOS Eligibility
Supply Group Homogeneity for ASVAB profile
Weight on ASVAB
% MOS_C020
% MOS_C015
% MOS_C010
% MOS_C005
R_C020
R_C015
R_C010
R_C005

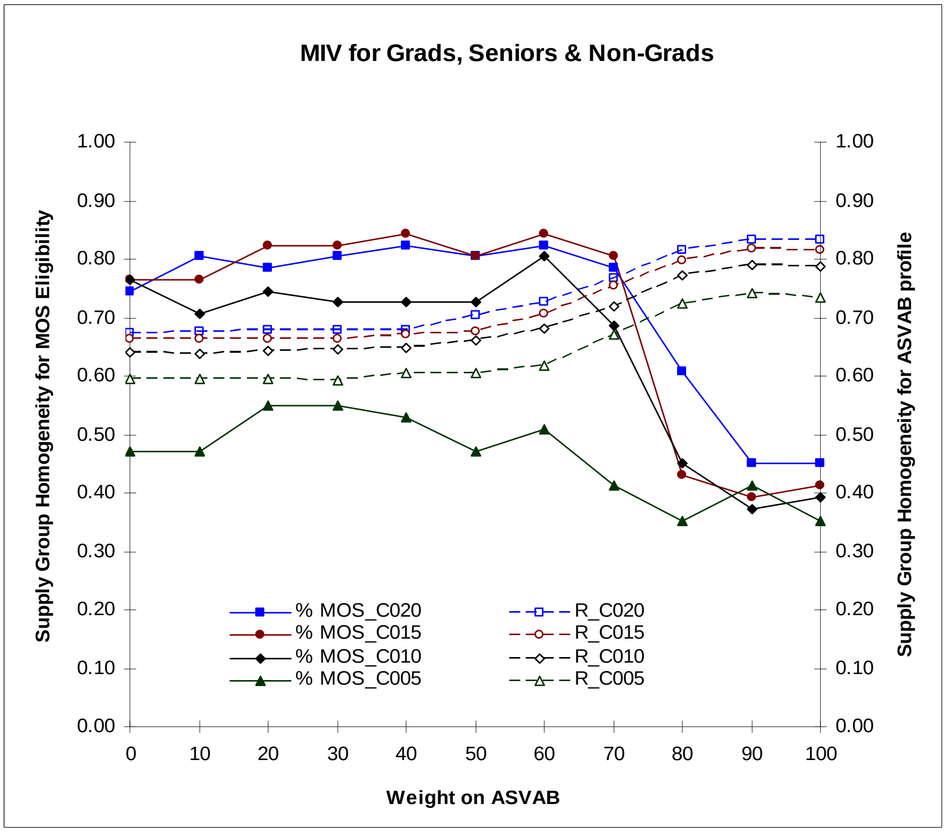


M3B Grads
Supply Group Homogeneity for MOS Eligibility
Supply Group Homogeneity for ASVAB profile
Weight on ASVAB
% MOS_C020
% MOS_C015
% MOS_C010
% MOS_C005
R_C020
R_C015
R_C010
R_C005



M3B Seniors
Supply Group Homogeneity for MOS Eligibility
Supply Group Homogeneity for ASVAB profile
Weight on ASVAB
% MOS_C020
% MOS_C015
% MOS_C010
% MOS_C005
R_C020
R_C015
R_C010
R_C005


M3B Non-Grads
Supply Group Homogeneity for MOS Eligibility
Supply Group Homogeneity for ASVAB profile
Weight on ASVAB
% MOS_C020
% MOS_C015
% MOS_C010
% MOS_C005
R_C020
R_C015
R_C010
R_C005


MIV for Grads, Seniors & Non-Grads
Supply Group Homogeneity for MOS Eligibility
Supply Group Homogeneity for ASVAB profile
Weight on ASVAB
% MOS_C020
% MOS_C015
% MOS_C010
% MOS_C005
R_C020
R_C015
R_C010
R_C005